Design of Beams using Charts.

نسألكم الدعاء

IF you download the Free ***APP.*** **RC Structures** *on your smart phone or tablet, you will be able to play illustrative movies For any paragraph that has a QR code icon*

اذا حملت تطبيق **RC Structures** على تليفونك المحمول او اللوح السطحى ستستطيع أن تشغل أفلام شرح للمقاطع التى تحتوى على رمز

Design of Beams using Charts. Table of Contents.

Design of Beams using
Limits states Design Method.

التصميم بطريقه حالات الحدود .

Design using Limits states Design Method. (*L.S.D.M.*)

يتم التصميم بحيث نضمن أن المنشأ لن يتعدى أى حاله من حالات الحدود التاليه :

1 – *Ultimate Strength Limit State.* ١ـ حد المقاومه القصوى

اذا تعدت الاجهادات حدود المقاومه القصوى للمواد ممكن بعدها ان يحدث انهيار .

2 – *Stability Limit State.* ٢ـ حد الاستقرار .

لاستقرار المنشأ توجد عده عوامل يجب التأكد انها لن تزيد عن الحد الاقصى لها

مثل الانبعاج (*Buckling*) و مثل الانقلاب (*Overturning*)

و مثل الانزلاق (*Sliding*) و مثل الرفع لاعلى (*Uplift*)

اذا كانت اى حاله من الحالات السابقه تعدت الحد الاقصى لها

ممكن بعدها أن يحدث أنهيار للمنشأ ناتج عن عدم الاتزان .

3 – *Serviceability Limit State.* ٣ـ حد التشغيل .

و هى حدود مثل :

حد التشكيل و الترخيم *Deformation & Deflection Limit State.*

حد التشرخ . *Cracking Limit State.*

اذا زاد مقدار التشكيل و الترخيم او عرض الشروخ عن حدود التشغيل

سيؤثر ذلك على استخدام عناصر المنشأ و فى بعض الاحيان يؤثر على سلامته .

Design of Beams.

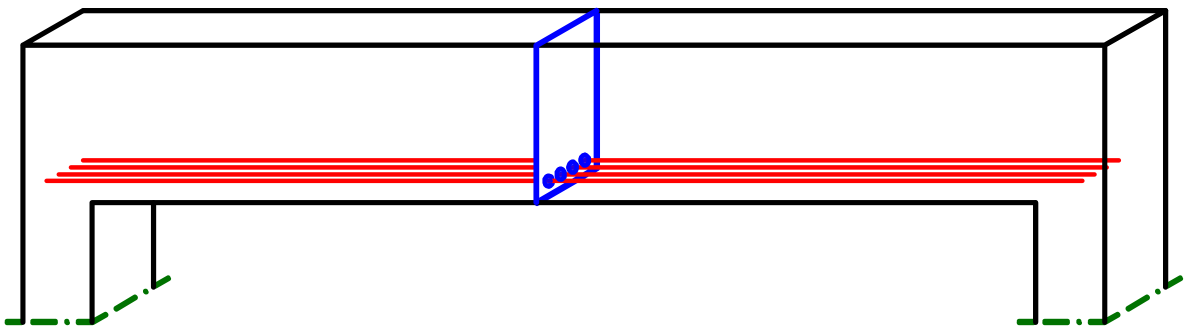
تصميم الكمره هو تحديد الابعاد الخرسانيه و كميه حديد التسليح اللازم لمقاومه أكبر عزم ممكن أن يؤثر عليها .

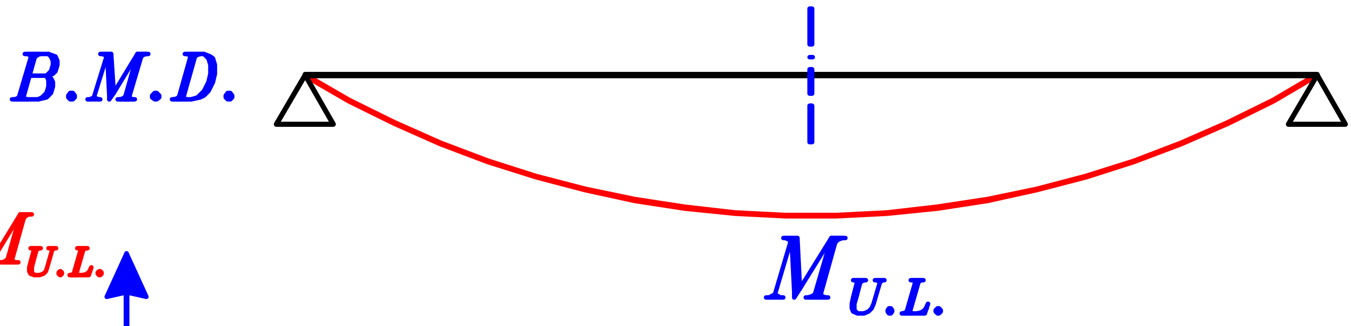
و نصمم فى الكمره القطاعات التى تسمى *Critical Sections* و هى القطاعات التى يؤثر عليها أكبر *moment* سفلى و اكبر *moment* علوى .

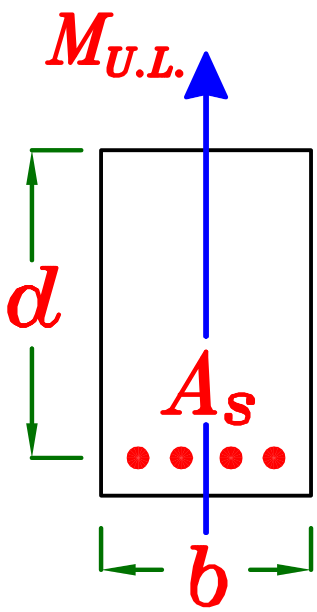
لتصميم هذه القطاعات نحدد ابعاد القطاع و كميه الحديد اللازمه لمقاومه ال *moment* المؤثر على القطاع .

ثم نكمل باقى قطاعات الكمره بنفس ابعاد هذا القطاع و نكمل الحديد بنفس كميه حديد هذا القطاع .

فنضمن بهذا ان باقى القطاعات *safe* لانه سيكون عليها *moment* اقل مما ستتحمله .







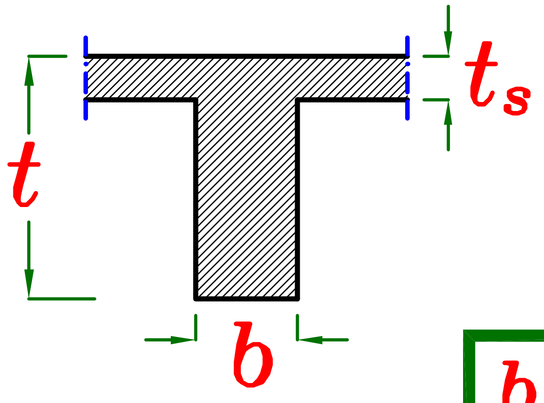
نصمم القطاع ليتحمل $M_{U.L.}$ المؤثر عليه .

نفرض قيمه b و نحدد قيمه كلا من d , A_s من التصميم .

لمقاومه $M_{U.L.}$ اذا اخترنا قيمه d كبيره ستكون ال A_s صغيره .

و اذا اخترنا قيمه d صغيره ستكون ال A_s كبيره .

لتصميم الكمرات توجد عده اشتراطات .



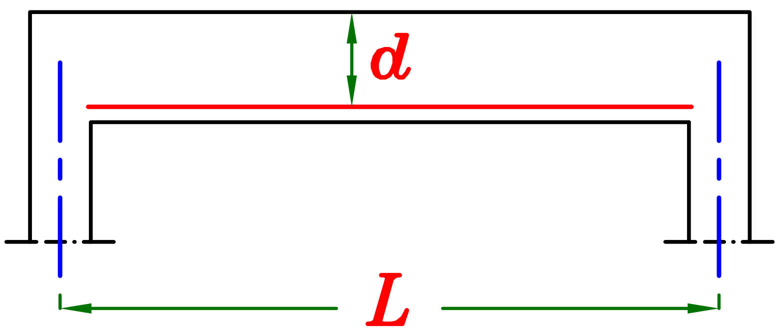
حتى نضمن ان الكمره هى التى تحمل البلاطه

$$t \nless 3\,t_s$$

حتى نضمن عدم حدوث انبعاج جانبى للكمره

$$b \nless 100\,mm$$

$$b \nless 0.75\,t_s$$



IF $\dfrac{L}{d} > 4.0$ $\longrightarrow$ ***Slender Beam.***

IF $\dfrac{L}{d} \leqslant 4.0$ $\longrightarrow$ ***Deep Beam.***

كل الكمرات التى سيتم دراستها فى هذه الملفات هى *Slender Beams*

Factor Of Safety (F.O.S.)

* F.O.S. For Loads.

عند التصميم يتم ضرب قيم القوى المؤثره على المنشأ فى معاملات (Factors)
حتى نعمل على زياده الـ bending moments على الكمرات
بحث يتم التصميم على قيم bending moments اكبر من القيم الفعليه
فتكون ابعاد القطاعات و كميات حديد التسليح المستنتجه من الـ design كبيره
مما يعمل على زياده الامان فى المبنى .

Types of Loads.

1- Dead Loads (D) الاحمال الميته

2- Live Loads (L) الاحمال الحيه

3- Wind Loads (W) الاحمال الناتجه عن تأثير الرياح على المبنى

4- Seismic Loads (S) الاحمال الناتجه عن تأثير الزلازل على المبنى

Cases of Loading.

و هى عباره عن احتمال جمع الاحمال المختلفه على المبنى فى نفس الوقت
بحيث تنتج اكبر bending moments ممكن ان تؤثر على الكمرات لنصمم عليها .
و يتم ضرب قيمه كل قوه من القوى المؤثره على المبنى فى Factor ثم جمعهم .

عند التصميم يتم ضرب قيم القوى المؤثره على المنشأ فى معاملات

1- IF Dead & Live Loads

To Increase Loads $= 1.4*D + 1.6*L$

or $= 1.5*(D+L)$ IF $L \leqslant 0.75\,D$

To Decrease Loads $= 0.9*D$

2- IF Dead , Live & Wind Loads.

$$= 0.8*(1.4*D + 1.6*L + 1.6*W)$$

3- IF Dead , Live & Seismic Loads.

$$= 0.8*(1.4*D) + \alpha*L + S$$

$\alpha = 0.25$ فى حاله المبانى السكنيه

$\alpha = 0.50$ فى حاله المدارس و المستشفيات و المسارح و الجراجات

$\alpha = 1.0$ فى حاله الصوامع و الخزانات و المكتبات و المخازن

فى حاله وجود احمال ناشئه عن الرياح و احمال ناشئه عن الزلازل

نأخذ فقط الحمل الاكبر منهما و لا يجوز جمع أحمال الرياح و الزلازل معاً

$$\left.\begin{aligned} &= 0.8*(1.4*D + 1.6*L + 1.6*W) \\ &= 0.8*(1.4*D) + \alpha*L + S \end{aligned}\right] \text{الاكبر}$$

ملحوظه فى هذا الملف سيم دراسه تصميم الكمرات على الاحمال الرأسيه فقط اى الاحمال الميته و الحيه فقط. بدون احمال رياح او زلازل حيث سيتم دراستهم لاحقا .

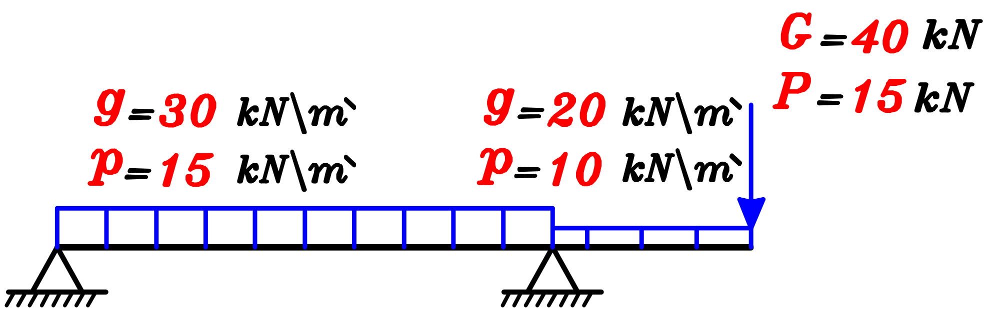
Cases of Loading due to Dead & Live Loads.

Load (To Increase) $= 1.4\ D.L. + 1.6\ L.L.$

$= 1.5\ (D.L. + L.L.)$ IF $L.L. \leqslant 0.75\ D.L.$

Load (To Decrease) $= 0.9\ D.L.$

Example.



Make Cases of Loading To draw max.–max. B.M.D. in U.L. Design Method

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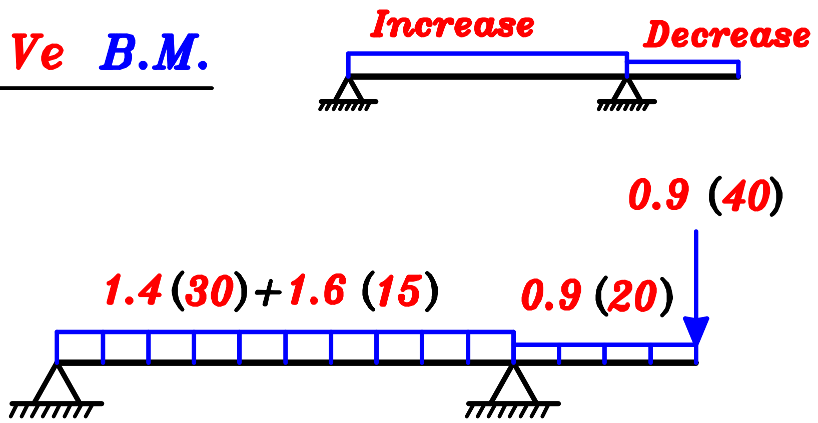
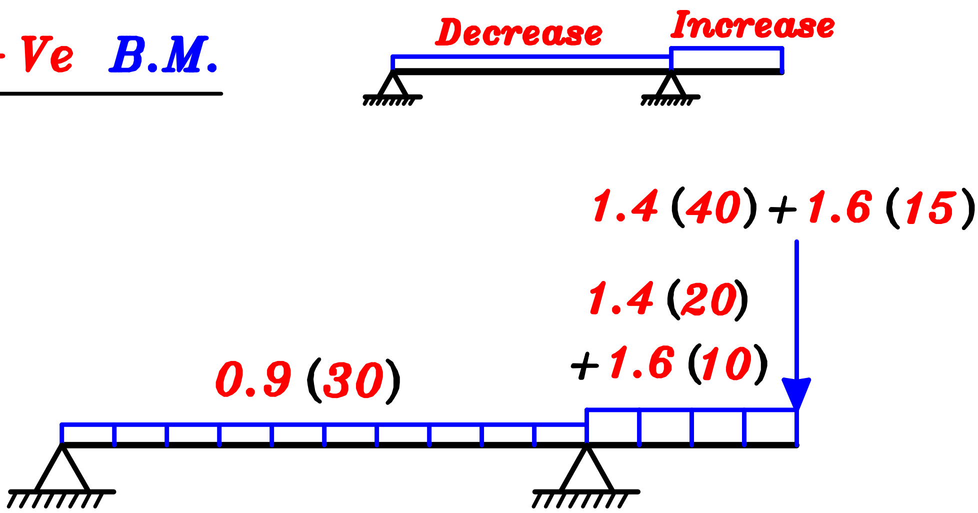
max. +Ve B.M.



max. –Ve B.M.



* F.O.S. For Materials.

1- Case of bending moment only (M) or Tension only (T)
or Axial tension & bending moment $(M+T)$
or Shear (Q) only or Torsion only (M_t) or Shear & Torsion $(Q+M_t)$

$$\boxed{\gamma_c = 1.5 \quad , \quad \gamma_s = 1.15} \quad \checkmark\checkmark$$

2- Case of Axial compression Force only. (P).

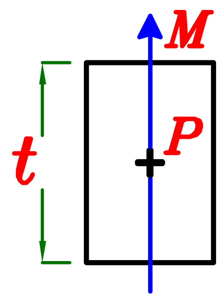
$$\boxed{\gamma_c = 1.75 \quad , \quad \gamma_s = 1.34}$$

3- Case of Axial compression Force and bending moment $(M+P)$

$$\boxed{e = \frac{M}{P}}$$

$$\gamma_c \ (\text{Concrete}) = 1.5\left[\left(\frac{7}{6}\right) - \frac{(e\backslash t)}{3}\right] \geq 1.5$$

$$\gamma_s \ (\text{Steel}) = 1.15\left[\left(\frac{7}{6}\right) - \frac{(e\backslash t)}{3}\right] \geq 1.15$$



$\therefore$ Allowable stress For Concrete $= \dfrac{F_{cu}}{\gamma_c}$

Allowable stress For Steel $= \dfrac{F_y}{\gamma_s}$

We have three types of Sections.

$$c_b = \frac{600}{600 + (F_y \backslash \gamma_s)} * d$$

1- Balanced Section. $\boxed{c = c_b}$
(Brittle Failure)

2- Under Reinforced Section. $\boxed{c < c_b}$
(Ductile Failure)

3- Over Reinforced Section. $\boxed{c > c_b}$
(Brittle Failure)

ملحوظه مهمه جدا

دائماً فى التصميم بطريقه الـ U.L.D.M. يجب أن يكون القطاع
Under Reinforced Section.

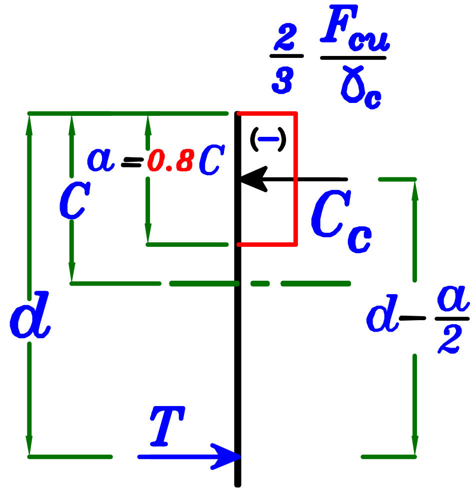
Properties of Under Reinforced Section.

① $c \leqslant c_{max.}$

where:

$$\boxed{c_{max} = \frac{2}{3}\, c_b}$$

$$\therefore \boxed{c_{max} = \frac{2}{3}\left[\frac{600}{600 + (F_y \backslash \gamma_s)} * d\right]}$$



② $a \leqslant a_{max.}$

$$\boxed{a_{max.} = 0.8\, C_{max.}}$$

$$\therefore \boxed{a_{max} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (F_y \backslash \gamma_s)} * d\right]}$$

③ $a \geqslant a_{min}$

$$\boxed{a_{min} = 0.1\, d}$$

IF $a < 0.1\, d \xrightarrow{\text{Take}} a = 0.1\, d$

④ $A_s \leqslant A_{s_{max.}}$

Where:

$$\boxed{\mu = \frac{A_s}{bd} = \frac{\text{مساحه الحديد الرئيسى}}{\text{مساحه الخرسانه}}}$$

$\mu_{max.} = \frac{A_{s_{max.}}}{bd} \longrightarrow$ Code Page (4–7) Table (1–4)

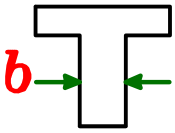
$$\boxed{A_{s_{max.}} = \mu_{max.}\, b\, d}$$

⑤ $A_s \geqslant A_{s\,min.}$

$$\mu_{min.} = \left\{ \begin{array}{c} \dfrac{1.1}{F_y} \\[2ex] 0.225 * \dfrac{\sqrt{F_{cu}}}{F_y} \end{array} \right\}$$ الأكبر

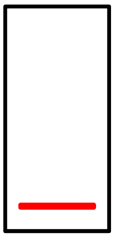
اذا كان $\boxed{F_{cu} \geqslant 25\ N/mm^2}$ تكون $\boxed{0.225 * \dfrac{\sqrt{F_{cu}}}{F_y}}$ هى الاكبر

دائما نقارن قيمه $A_{s\,req.}$ المحسوبه من التصميم بقيمه $\boxed{\mu_{min.} * b * d}$

حيث b هى اصغر عرض فى القطاع 

١ـ اذا كانت $A_{s\,req.} \geqslant \mu_{min.} * b * d$

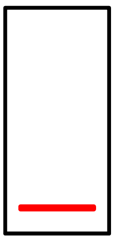
نضع قيمه $A_{s\,req.}$ فى الكمره و تنفذ على ذلك .



$A_{s\,req.}$

٢ـ اذا كانت $A_{s\,req.} < \mu_{min.} * b * d$

نضع قيمه $A_{s\,min}$ فى الكمره و تنفذ على ذلك .



$A_{s\,min}$

حيث قيمه $A_{s\,min}$ التى تضمن التحكم فى تشرخ الكمره و ضمان وجود ممطوليه

$A_{s\,min.}$ (For Beams) $=$

$$\left. \begin{array}{l} \left. \begin{array}{l} \mu_{min.}\ b\ d \\ 1.3\ A_{s\,req.} \end{array} \right\} \text{الأقل} \\[2ex] \begin{array}{l} \text{st. } 360/520 \\ \text{st. } 400/600 \end{array} \quad \dfrac{0.15}{100}\ b\ d \\[2ex] \text{st. } 240/350 \quad \dfrac{0.25}{100}\ b\ d \end{array} \right\} \text{الأكبر}$$

Example.

$F_{cu} = 25\ kN/m^2$, $F_y = 360\ kN/m^2$

From design of a given Sec. $(250 * 700)$

Found that $A_{s\,req.} = 300\ mm^2$ Check $A_{s_{min.}}$

$$\mu_{min.} = \left\{ \begin{array}{l} \dfrac{1.1}{F_y} \\ 0.225 * \dfrac{\sqrt{F_{cu}}}{F_y} = \dfrac{1.125}{F_y} \end{array} \right\} = \overset{\text{الأكبر}}{\dfrac{1.125}{F_y}}$$

Calculate

$$\mu_{min.}\, b\, d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\, d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 250 * 650 = 507.8\ mm^2$$

$\therefore A_{s_{req.}} < A_{s_{min.}}$ $\therefore$ Take $A_s = A_{s_{min.}}$

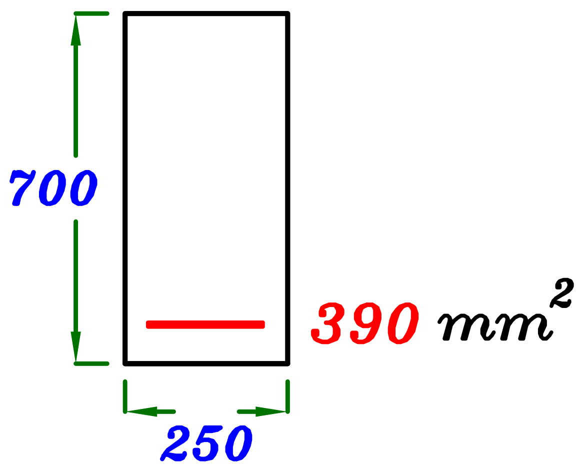
$$A_{s_{min.}} = 0.225 * \frac{\sqrt{F_{cu}}}{F_y}\, b\, d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 250 * 650 = 507.8$$

$$1.3\ A_{s_{req.}} = 1.3 * 300 = 390$$

الأقل $= 390$

st. 360/520 $\dfrac{0.15}{100}\, b\, d = \dfrac{0.15}{100} * 250 * 650 = 243.7$

الأكبر $= 390\ mm^2$



⑥ $A_{s`} \leq A_{s`max.}$ IF we are using $A_{s`}$

where $\boxed{A_{s`max.} = 0.4 A_s}$

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⑦ $d \geq d_{min.}$

$d_{min.}$ هو أقل عمق للقطاع يكون فية القطاع Under Reinforced Section

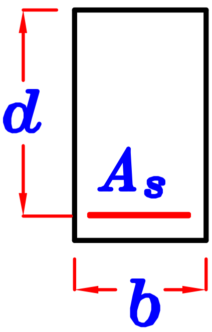
و إذا قلت قيمة ال d عن ال $d_{min.}$ يصبح القطاع Over Reinforced Section

IF $M_{U.L.}$ is given , We can get $d_{min.}$ by using

without $A_{s`}$

$$M_{U.L.} = \frac{2}{3} \frac{F_{cu}}{\gamma_c} a_{max} \, b \left(d_{min.} - \frac{a_{max}}{2}\right)$$

$$\text{OR} \quad M_{U.L.} = R_{max.} \frac{F_{cu}}{\gamma_c} b \, d^2_{min.}$$

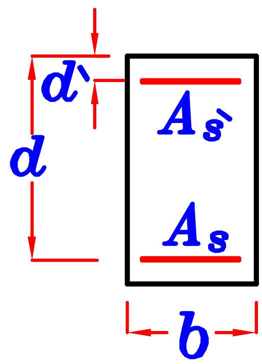


Code Page (4−6) Table(4−1)

IF $M_{U.L.}$ is given , by using $A_{s`}$

$$M_{U.L.} = \frac{2}{3} \frac{F_{cu}}{\gamma_c} a_{max} \, b \left(d_{min} - \frac{a_{max}}{2}\right) + A_{s`} \frac{F_y}{\gamma_s} \left(d_{min} - d`\right)$$

$$\text{OR} \quad M_{U.L.} = R_{max.} \frac{F_{cu}}{\gamma_c} b \, d^2_{min.} + A_{s`} \frac{F_y}{\gamma_s} \left(d_{min} - d`\right)$$



⑧ $M_{U.L.} \leqslant M_{U.L.max}$

اذا كان معطى عمق القطاع $d = ✓$ يجب أن لا يزيد العزم المؤثر عن $M_{U.L.max}$

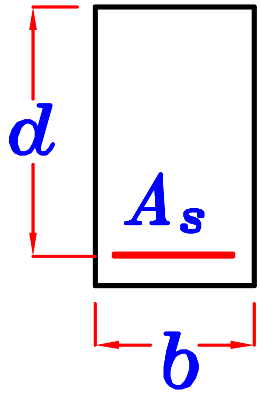
اذا زادت قيمة العزم المؤثر عن $M_{U.L.max}$ يصبح القطاع Over Reinforced Section

IF d is given , We can get $M_{U.L.max}$ by using

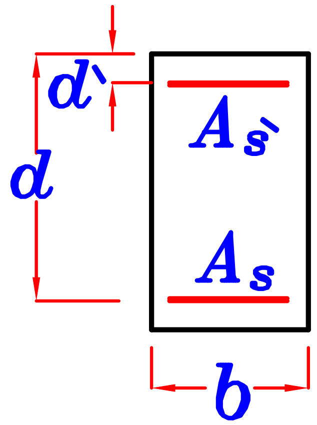
without $A_{s`}$

$$M_{U.L.max} = \frac{2}{3}\,\frac{F_{cu}}{\gamma_c}\,a_{max}\,b\left(d - \frac{a_{max}}{2}\right)$$

$$\text{OR}\quad M_{U.L.max} = R_{max.}\,\frac{F_{cu}}{\gamma_c}\,b\,d^2$$



with $A_{s`}$



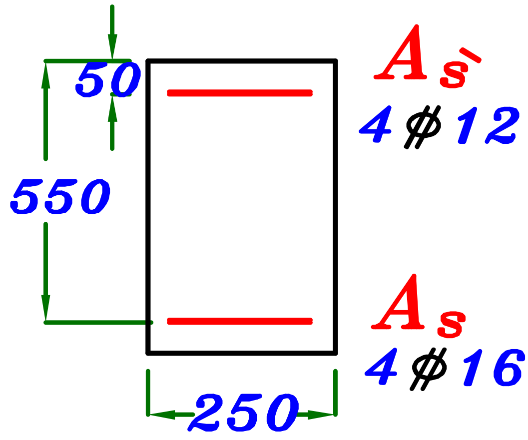
$$M_{U.L.max} = \frac{2}{3}\,\frac{F_{cu}}{\gamma_c}\,a_{max}\,b\left(d - \frac{a_{max}}{2}\right) + A_{s`}\,\frac{F_y}{\gamma_s}\,(d - d`)$$

$$\text{OR}\quad M_{U.L.max} = R_{max.}\,\frac{F_{cu}}{\gamma_c}\,b\,d^2 + A_{s`}\,\frac{F_y}{\gamma_s}\,(d - d`)$$

Example.

$F_{cu} = 25\ N/mm^2$ st. 360/520

Get $M_{U.L._{max}}$



$$A_s = 4\phi 16 = 804\ mm^2$$

$$A_{s`} = 4\phi 12 = 452\ mm^2$$

$$a_{max} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600+(F_y \backslash \gamma_s)} * d\right]$$

$$a_{max} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600+\left(\frac{360}{1.15}\right)} * 550\right] = 192.7 mm$$

$$M_{U.L._{max}} = \frac{2}{3}\frac{F_{cu}}{\gamma_c}\ a_{max}\ b\ \left(d - \frac{a_{max}}{2}\right) + A_{s`}\frac{F_y}{\gamma_s}(d - d`)$$

$$\therefore M_{U.L._{max}} = \frac{2}{3}\left(\frac{25}{1.5}\right)(192.7)(250)\left(550 - \frac{192.7}{2}\right) + 452\left(\frac{360}{1.15}\right)(550-50)$$

$$= 313576590\ N.mm = 313.576\ kN.m$$

OR Get $R_{max.} = 0.194$ Code Page (4−7) Table(1−4)

$$M_{U.L._{max}} = R_{max.}\frac{F_{cu}}{\gamma_c}\ b\ d^2 + A_{s`}\frac{F_y}{\gamma_s}(d - d`)$$

$$M_{U.L._{max}} = 0.194\left(\frac{25}{1.5}\right)(250)(550)^2 + 452\left(\frac{360}{1.15}\right)(550-50)$$

$$= 315268659\ N.mm = 315.268\ kN.m$$

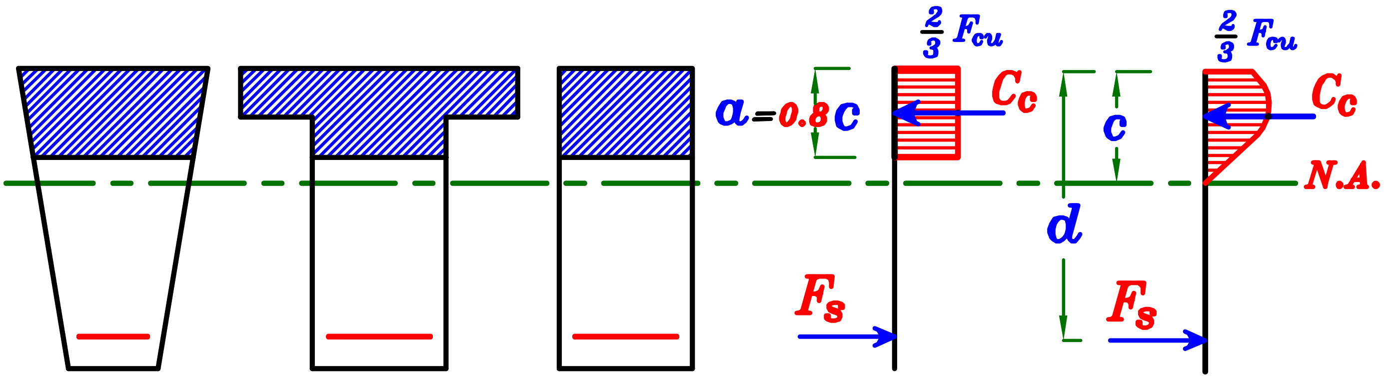
يوجد فى الكود المصرى جدول يعطى قيم لمعلملات R_{max} & μ_{max} , $\frac{c_{max}}{d}$

Code Page (4–6) Table (4–1)

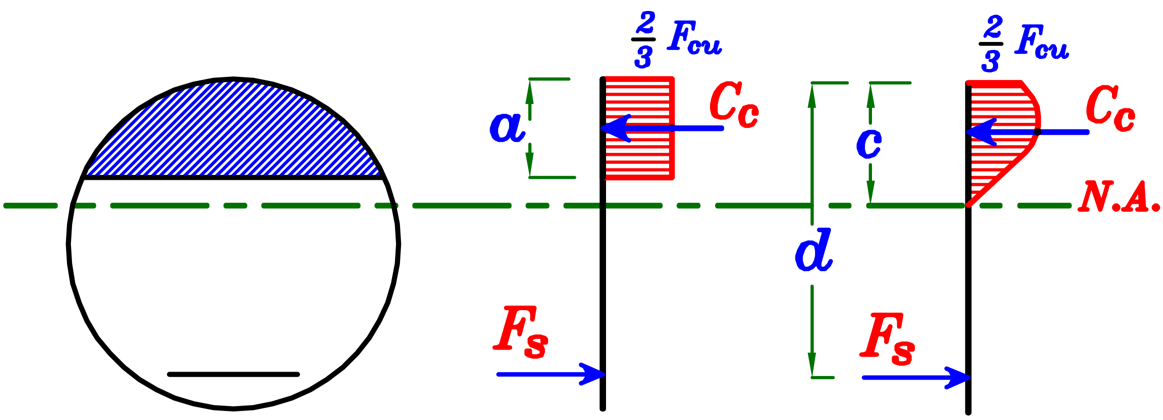
رتبه الحديد	$\frac{c_{max}}{d}$	μ_{max}	R_{max}
st. 240/350	0.50	$8.56 \times 10^{-4} \times F_{cu}$	0.214
st. 280/450	0.48	$7.0 \times 10^{-4} \times F_{cu}$	0.208
st. 360/520	0.44	$5.0 \times 10^{-4} \times F_{cu}$	0.194
st. 400/600	0.42	$4.31 \times 10^{-4} \times F_{cu}$	0.187
st. 450/520	0.40	$3.65 \times 10^{-4} \times F_{cu}$	0.180

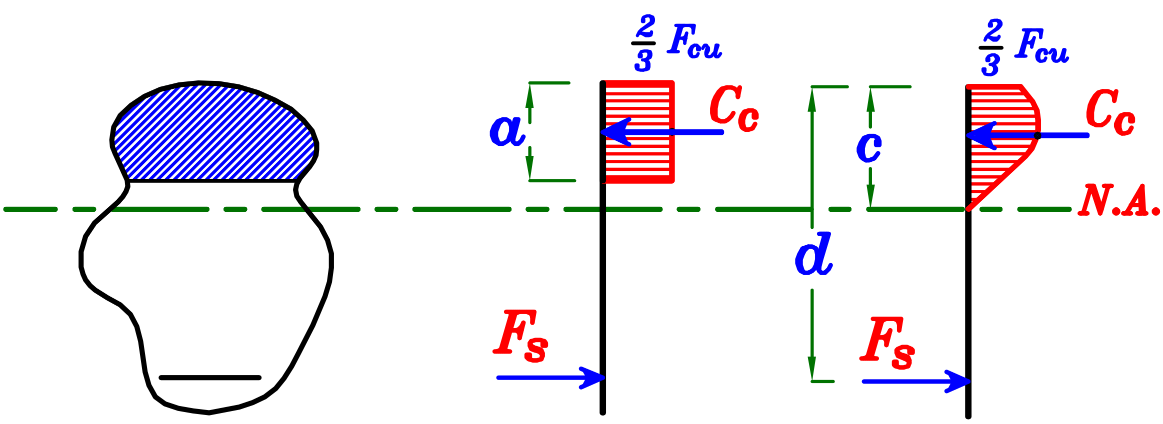
ملحوظه .

شكل ال *Equivalent Stress* المستنتج بحيث تكون قيمه و مكان محصله القوى له تساوى نفس قيمه و مكان محصله ال *Actual Stress* للقطاعات *R-Sec, T-Sec., L-Sec. & Trapezoidal Sec.* تكون قيمه $\boxed{a = 0.8\ C}$



اما اى شكل اخر مثل القطاعات الدائريه او غير منتظمه الشكل فيجب علينا لتحديد قيمه a التى تجعل قيمه و مكان محصله القوى على الخرسانه لشكل ال *Equivalent Stress* هى نفس قيمه و مكان محصله القوى على الخرسانه لل *Actual Stress* و ذلك عن طريق التكامل . $\boxed{a \neq 0.8\ C}$

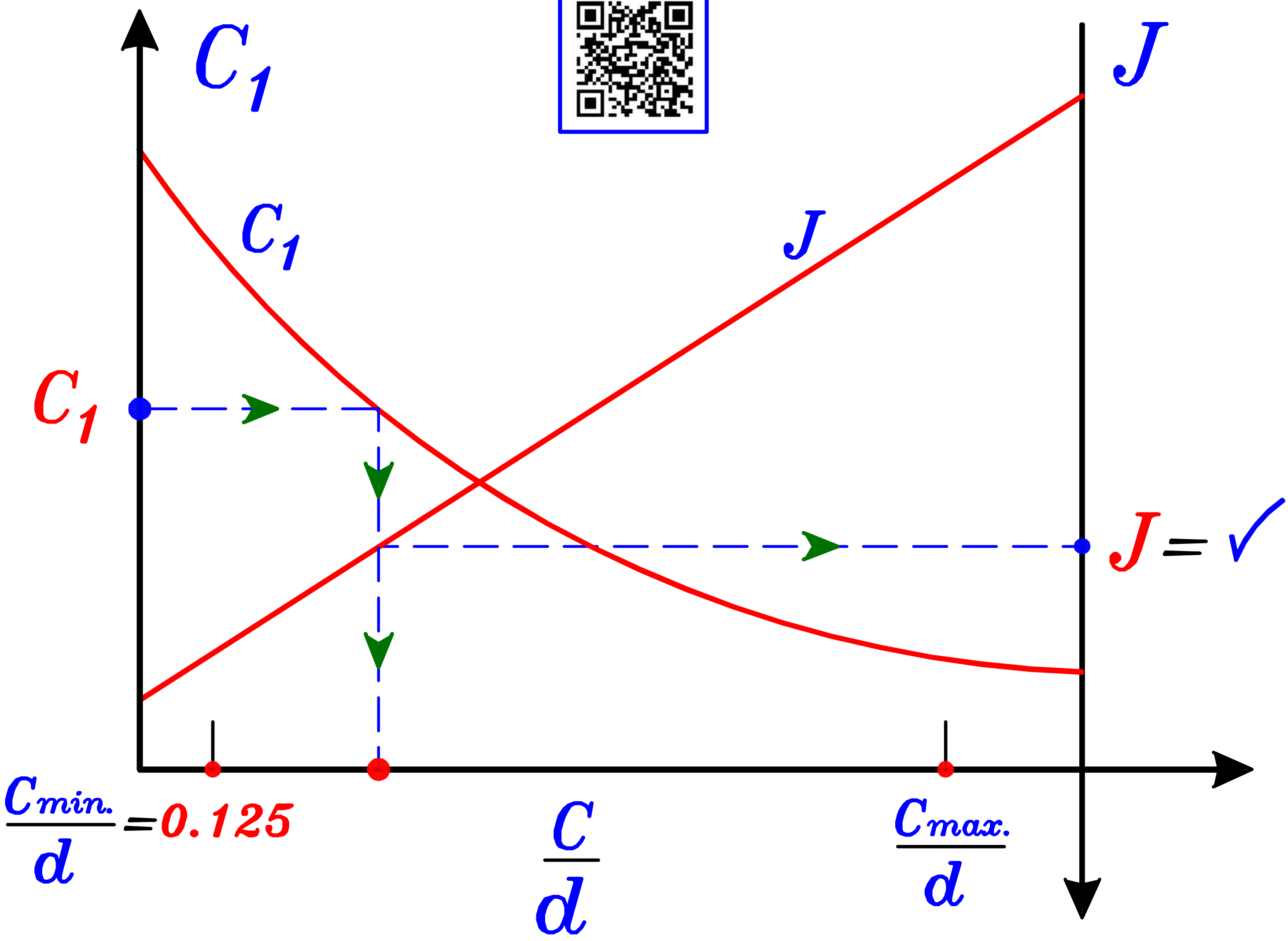




و فى هذا الملف سنتناول دراسه القطاعات المنتظمه فقط
R-Sec, T-Sec., L-Sec. & Trapezoidal Sec.

C_1 & J Chart.

Design Aids (ECCS) Page 2–21



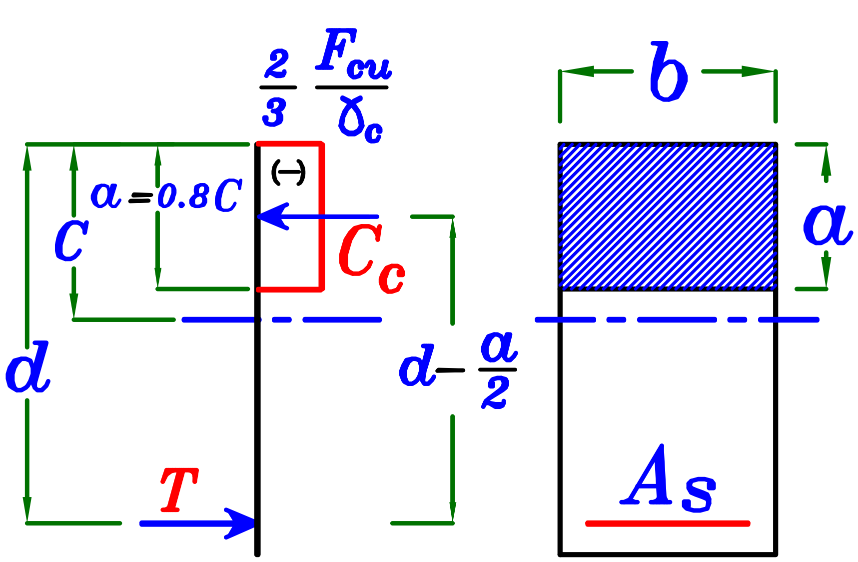
$$d = C_1 \sqrt{\frac{M_{U.L.}}{F_{cu}\ b}}$$

حفظ

$$A_s = \frac{M_{U.L.}}{J\ F_y\ d}$$

حفظ

① To get ((d))



$M_{U.L.}$ about Tension Force.

$$M_{U.L.} = \frac{2}{3}\frac{F_{cu}}{\gamma_c}\, a\, b\left(d - \frac{a}{2}\right)$$

$$M_{U.L.} = \frac{2}{3}\frac{F_{cu}}{\gamma_c}(0.8\,c)\, b\left(d - \frac{0.8\,c}{2}\right) = \frac{2}{3}\left(\frac{1}{\gamma_c}\right)(0.8)\, c\,\left(d - 0.4\,c\right) F_{cu}$$

$$M_{U.L.} = \frac{2}{3}\left(\frac{1}{\gamma_c}\right)(0.8)\, c\, d\left(1 - 0.4\frac{c}{d}\right) F_{cu}\, b \qquad \text{Multiply by } \frac{d}{d}$$

$$M_{U.L.} = \frac{2}{3}\left(\frac{1}{\gamma_c}\right)(0.8)\frac{c}{d}\left(1 - 0.4\frac{c}{d}\right) F_{cu}\, b\, d^2$$

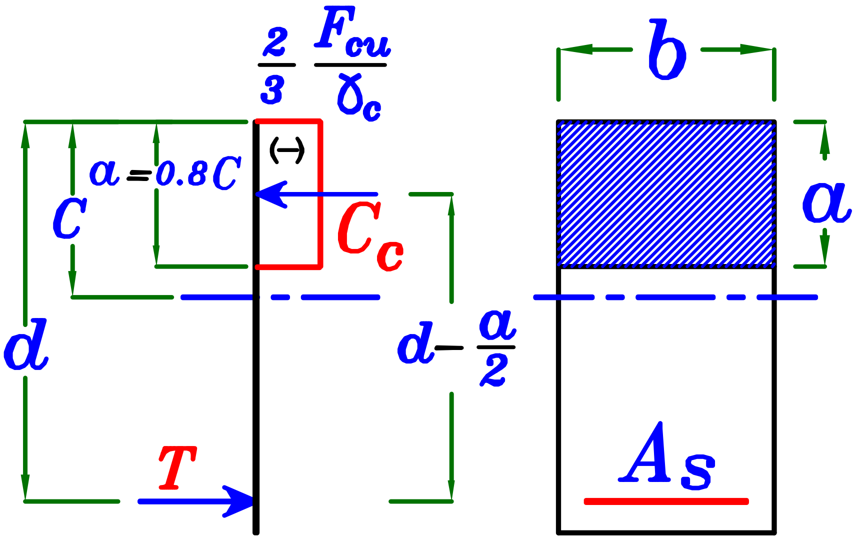
$$\therefore d^2 = \frac{1}{\frac{2}{3}\left(\frac{1}{\gamma_c}\right)(0.8)\frac{c}{d}\left(1 - 0.4\frac{c}{d}\right)} * \frac{M_{U.L.}}{F_{cu}\, b}$$

$$\therefore d = \sqrt{\frac{1}{\frac{2}{3}\left(\frac{1}{\gamma_c}\right)(0.8)\frac{c}{d}\left(1 - 0.4\frac{c}{d}\right)}} * \sqrt{\frac{M_{U.L.}}{F_{cu}\, b}}$$

Take $\boxed{C_1 = \sqrt{\frac{1}{\frac{2}{3}\left(\frac{1}{\gamma_c}\right)(0.8)\frac{c}{d}\left(1 - 0.4\frac{c}{d}\right)}}}$ Factor depends on $\left(\frac{c}{d}\right)$

$$\boxed{d = C_1\sqrt{\frac{M_{U.L.}}{F_{cu}\, b}}}$$ حفظ

② To get ((A_s))



$M_{U.L.}$ about Compression Force.

$$M_{U.L.} = A_s \frac{F_y}{\gamma_s}\left(d - \frac{a}{2}\right)$$

$$M_{U.L.} = A_s \frac{F_y}{\gamma_s}\left(d - \frac{0.8\,c}{2}\right)$$

$$M_{U.L.} = A_s \frac{F_y}{\gamma_s}\left(d - 0.4\,c\right)$$

$$M_{U.L.} = A_s \frac{F_y}{\gamma_s}\, d \left(1 - 0.4\frac{c}{d}\right)$$

$$M_{U.L.} = \left(\frac{1}{\gamma_s}\right)\left(1 - 0.4\frac{c}{d}\right) A_s\, F_y\, d$$

Take $\boxed{J = \left(\frac{1}{\gamma_s}\right)\left(1 - 0.4\frac{c}{d}\right)}$ Factor depends on $\left(\frac{c}{d}\right)$

$$\therefore M_{U.L.} = J\, A_s\, F_y\, d$$

$$\boxed{A_s = \frac{M_{U.L.}}{J\, F_y\, d}}$$

حفظ

Important Notes.

$\frac{C}{d} = \frac{C_{max.}}{d} = 0.5$ at $C_1 = 2.64$ st. 240/350

$\frac{C}{d} = \frac{C_{max.}}{d} = 0.44$ at $C_1 = 2.78$ st. 360/520

$\therefore$ IF $C_1 < 2.64$ st. 240/350, $C_1 < 2.78$ st. 360/520 & st. 400/600 $\Big\}$ The section will be Over Reinforced. We have to increase Dimension OR use A_s'

$\frac{C_{min.}}{d} = 0.125$ IF $\frac{C}{d} \leqslant \frac{C_{min.}}{d} \longrightarrow C_1 \geqslant 4.85$

$\therefore$ Take $\frac{C}{d} = \frac{C_{min.}}{d} \longrightarrow C_1 = 4.85 \longrightarrow J = 0.826$

IF $C_1 \geqslant 4.85 \xrightarrow{\text{Take}} J = 0.826$

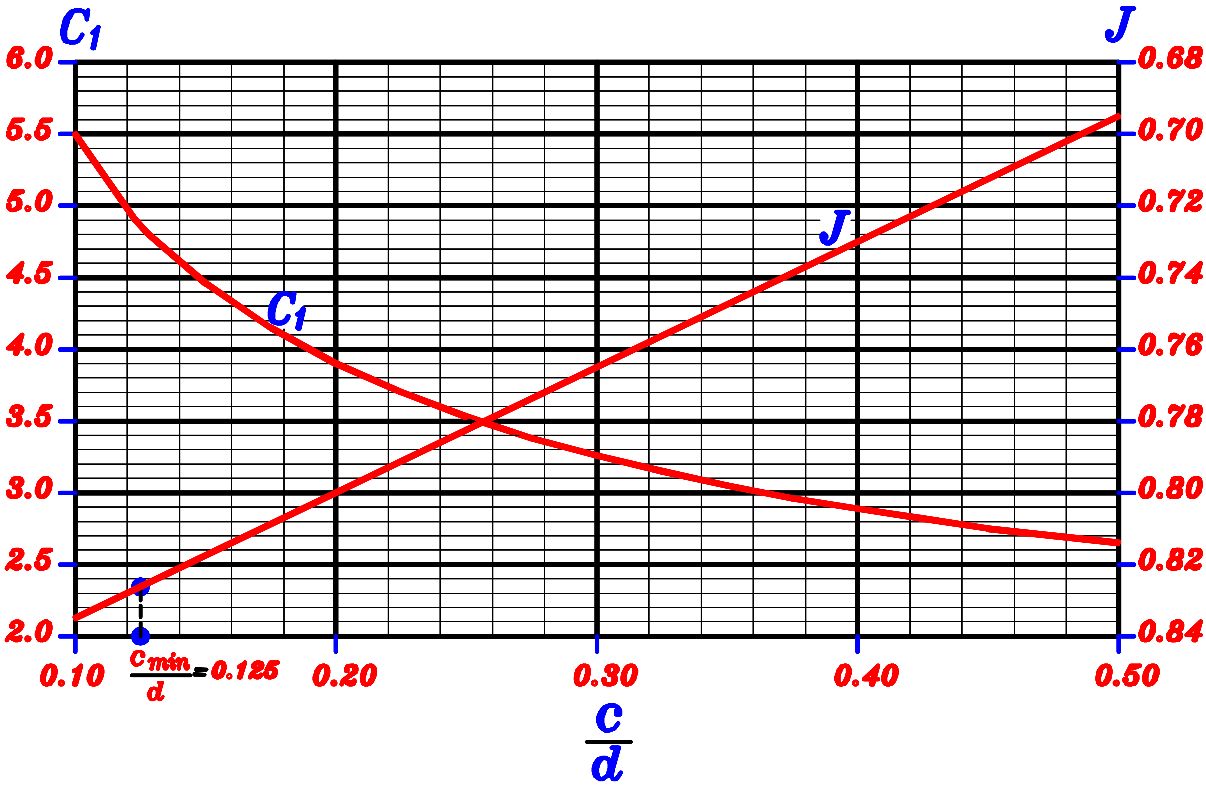
IF $C_1 \geqslant 4.85 \xrightarrow{\text{Take}} J = 0.826$

IF 2.64 st. 240/350, 2.78 st. 360/520 & st. 400/600 $\leqslant C_1 \leqslant 4.85 \xrightarrow[\text{From charts}]{\text{Get } J} J = \checkmark$

IF $C_1 <$ 2.64 st. 240/350, 2.78 st. 360/520 & st. 400/600 $\Big\}$ We have to increase Dimension OR use A_s'

ECCS page 2-21

$\frac{c}{d}$	C_1	J
0.1250	4.85	0.826
0.1375	4.64	0.821
0.1500	4.46	0.817
0.1625	4.29	0.813
0.1750	4.15	0.808
0.1875	4.02	0.804
0.2000	3.90	0.800
0.2125	3.79	0.795
0.2250	3.70	0.791
0.2375	3.61	0.786
0.2500	3.53	0.782
0.2625	3.45	0.778
0.2750	3.38	0.773
0.2875	3.32	0.769
0.3000	3.26	0.765
0.3125	3.20	0.760
0.3250	3.15	0.756
0.3375	3.10	0.752
0.3500	3.05	0.747
0.3625	3.00	0.743
0.3750	2.96	0.739
0.3875	2.92	0.734
0.4000	2.89	0.730
0.4125	2.85	0.726
0.4250	2.82	0.721
0.4375	2.78	0.717
0.4500	2.75	0.713
0.4625	2.72	0.708
0.4750	2.70	0.704
0.4875	2.67	0.700
0.5000	2.65	0.695



$$d = C_1 \sqrt{\frac{M_{U.L.}}{f_{cu}\, b}}$$

$$A_s = \frac{M_{U.L.}}{J\, f_y\, d}$$

ECCS page 2–21

$\frac{c}{d}$	C_1	J
0.1250	4.85	0.826
0.1375	4.64	0.821
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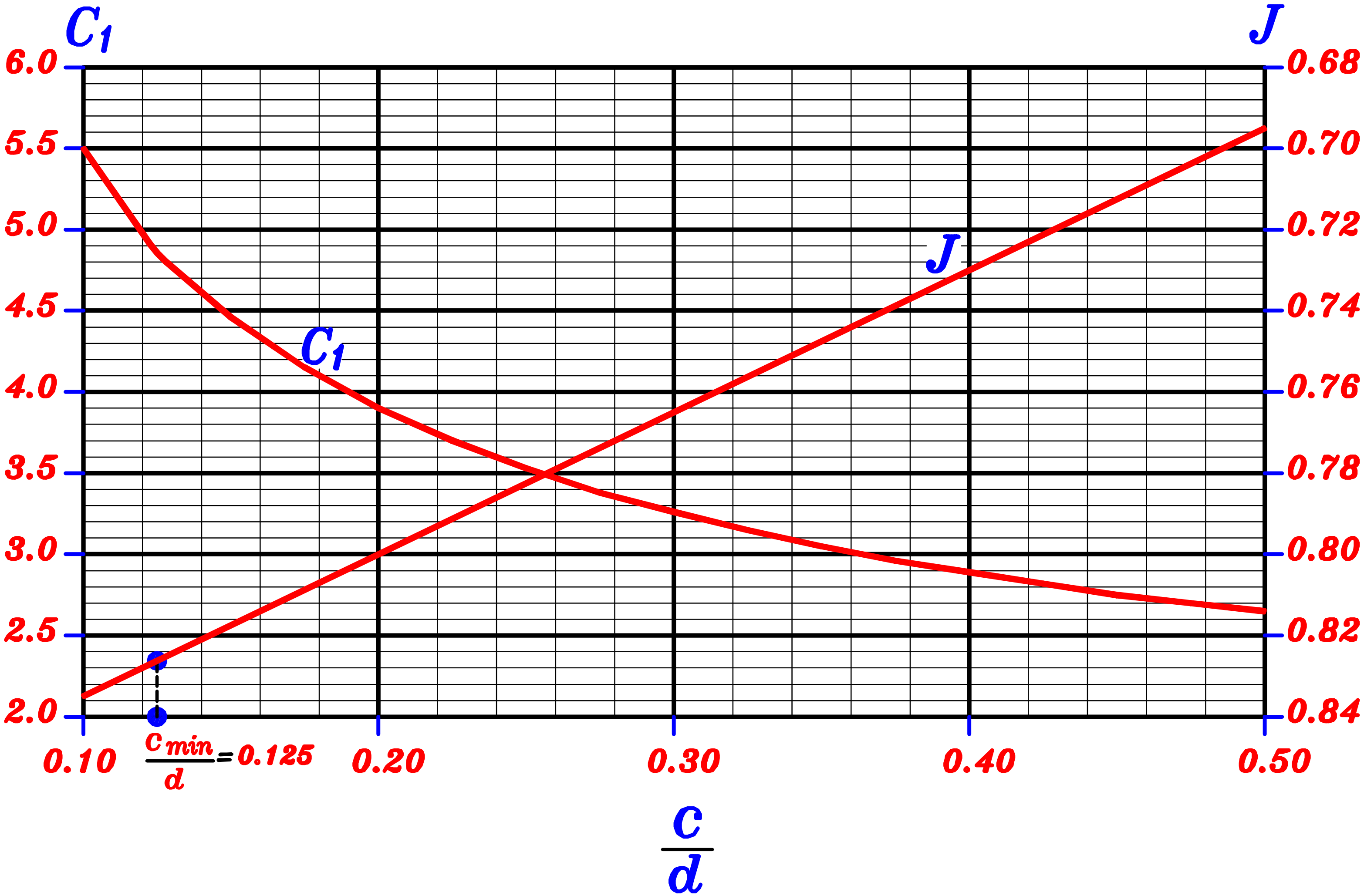

$$d = C_1 \sqrt{\frac{M_{U.L.}}{f_{cu}\, b}}$$

$$A_s = \frac{M_{U.L.}}{J\, f_y\, d}$$

c/d	C1	J
0.1250	4.85	0.826
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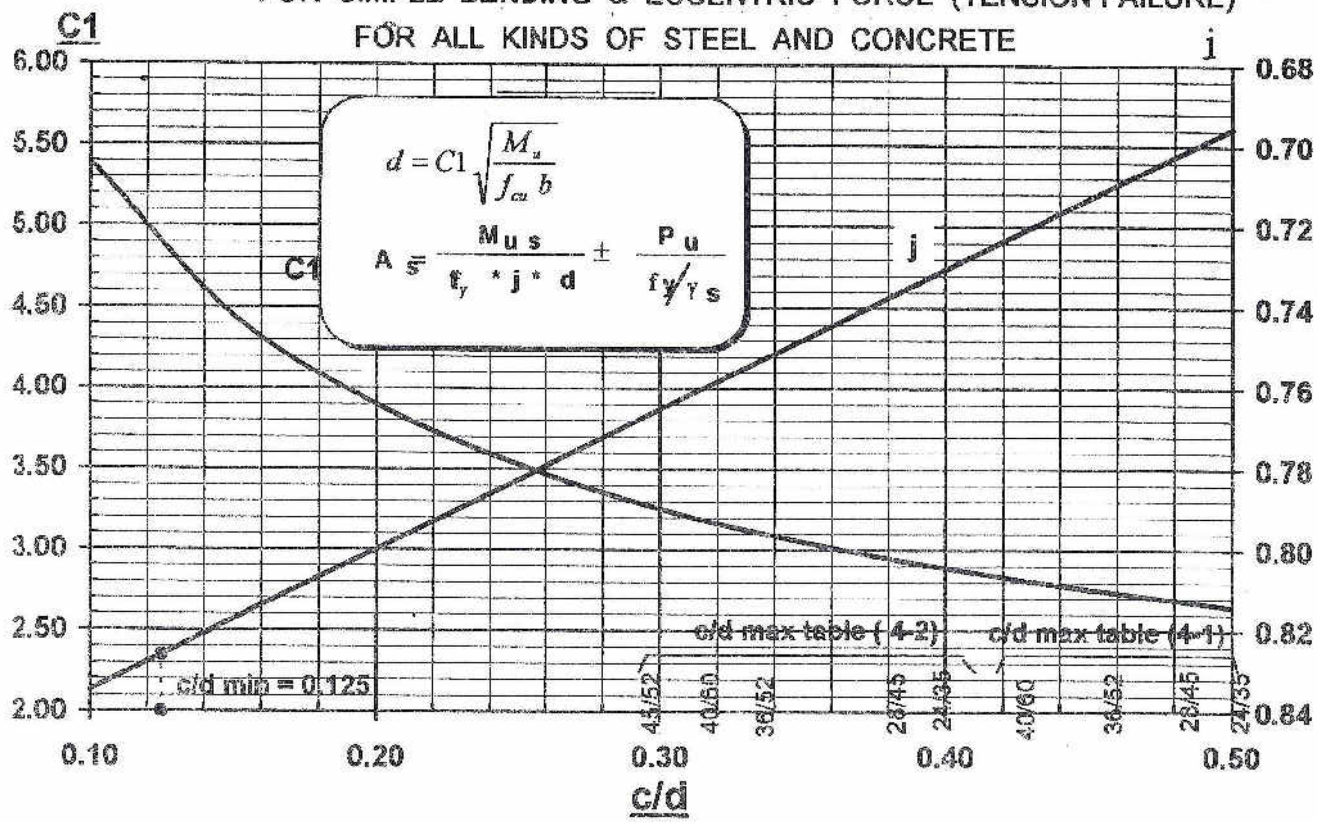
0.4375	2.78	0.717
0.4500	2.75	0.713
0.4625	2.72	0.708
0.4750	2.70	0.704
0.4875	2.67	0.700
0.5000	2.65	0.695

CHART(2-3):ULTIMATE LIMIT DESIGN CHARTS

FOR SIMPLE BENDING & ECCENTRIC FORCE (TENSION FAILURE)
FOR ALL KINDS OF STEEL AND CONCRETE



$$d = C1\sqrt{\frac{M_u}{f_{cu}\, b}}$$

$$A_s = \frac{M_{us}}{f_y * j * d} \pm \frac{P_u}{f_y/\gamma_s}$$

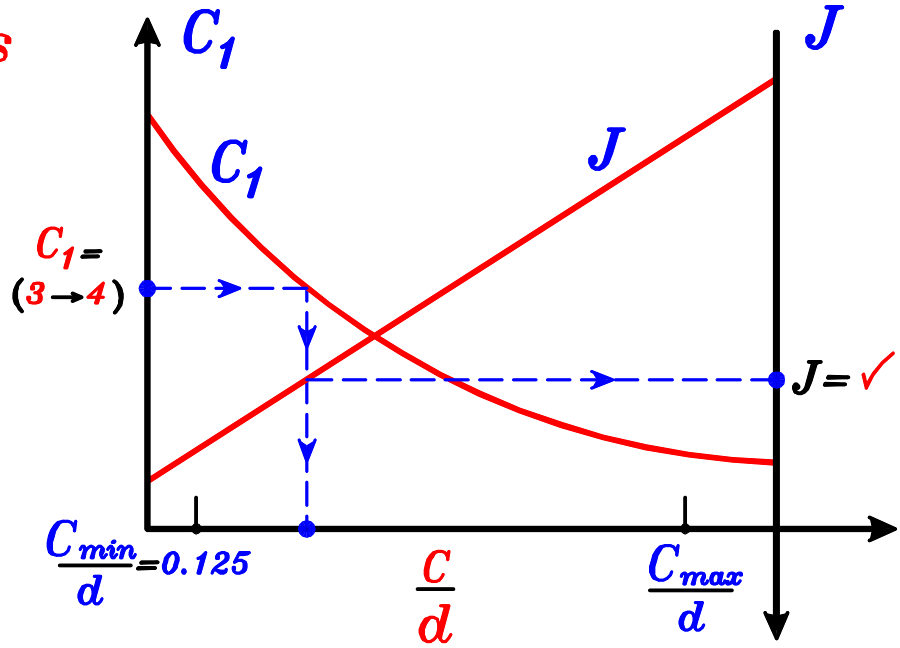
Design of Rectangular Section.

Type (1)

Given: F_{cu} , st. , b , $M_{U.L.}$

Req: d , A_s

Solution.



To Get the most economic section

For R–Sec. Take $\boxed{C_1 \simeq 3.50}$, $\boxed{J \simeq 0.78}$

For T–Sec. & L–Sec. Take $\boxed{C_1 \simeq 6.0}$, $\boxed{J \simeq 0.826}$

– Get d From $d = C_1 \sqrt{\frac{M_{U.L.}}{F_{cu}\, b}} = \checkmark$ mm تقرب لاقرب ٥٠ مم بالزياده

– Take $t = d + 50$ mm

– Get A_s From $A_s = \frac{M_{U.L.}}{J\, F_y\, d} = \checkmark\ mm^2$ قبل التقريب

– Check $A_{s_{min.}}$

Example.

$F_{cu} = 25\ N\backslash mm^2$ st. 360/520

$b = 0.25\ m$ $M_{U.L.} = 300\ kN.m$

Req: Get d , A_s

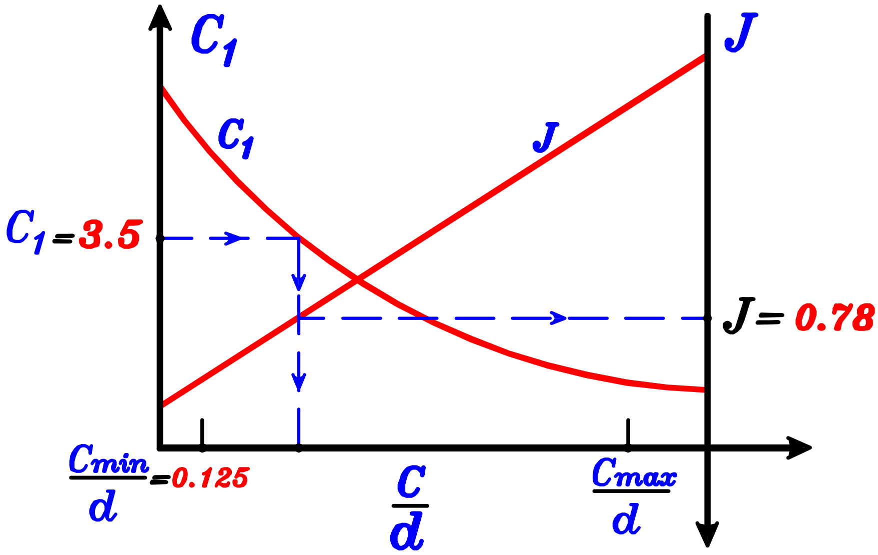
- Take C_1 between $(3.0 \longrightarrow 4.0)$

$C_1 = 3.5$

- From Design Aids

Page 2-21

$J = 0.78$



- Get $d = C_1 \sqrt{\frac{M_{U.L.}}{F_{cu}\ b}} = 3.5 \sqrt{\frac{300 * 10^6}{25 * 250}} = 766.8\ mm$

- Take $\boxed{d = 800\ mm}$, $\boxed{t = 850\ mm}$

- Get $A_s = \frac{M_{U.L.}}{J\ F_y\ d} = \frac{300 * 10^6}{0.78 * 360 * 766.8} = 1393.3\ mm^2$

- Check $A_{s_{min.}}$ $A_{s_{req.}} = 1393.3\ mm^2$

$$\mu_{min.}\ b\ d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\ d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 250 * 800 = 625.0\ mm^2$$

$\therefore A_{s_{req.}} > \mu_{min.}\ b\ d$

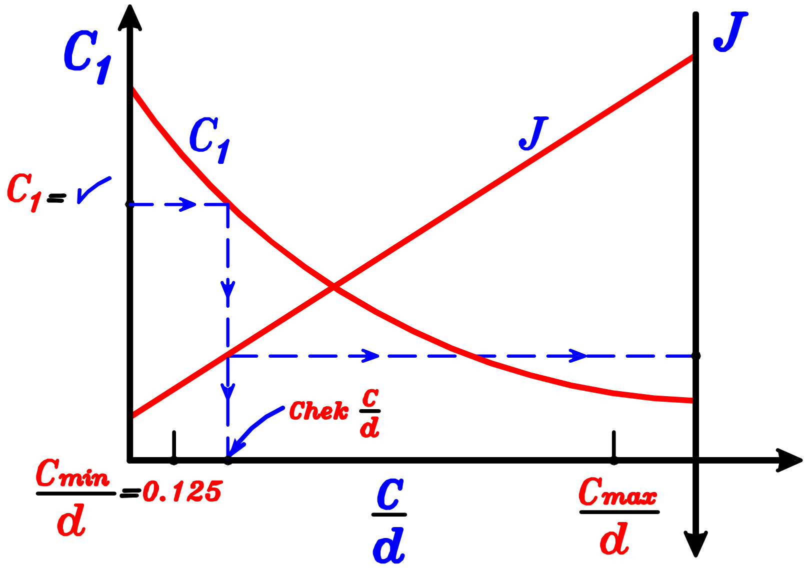
$\therefore$ Take $A_s = A_{s_{req.}} = 1393.3\ mm^2$ 4 ϕ 22

Type ②

Given: F_{cu} , st. , b , d , $M_{U.L.}$

Req: A_s , A_s` IF Required.

Solution:



– Get C_1 From $d = C_1 \sqrt{\frac{M_{U.L.}}{F_{cu}\, b}} \longrightarrow C_1 = ✓$

– From C_1 Get J From Charts.

① IF $C_1 \geqslant 4.85 \longrightarrow \frac{c}{d} \leqslant \frac{C_{min.}}{d} \xrightarrow{\text{Take}} J = 0.826$

$$\therefore \boxed{A_s = \frac{M_{U.L.}}{0.826\, F_y\, d}}$$ and check $A_{s_{min}}$

② IF $2.78 \leqslant C_1 < 4.85 \xrightarrow{\text{Get}} J$

$$\therefore \boxed{A_s = \frac{M_{U.L.}}{J\, F_y\, d}}$$ and check $A_{s_{min}}$

③ IF $C_1 < 2.78$ st. 360/520 & st. 400/600 ; $C_1 < 2.64$ st. 240/350 } We have to increase Dimension OR use $A_s`$

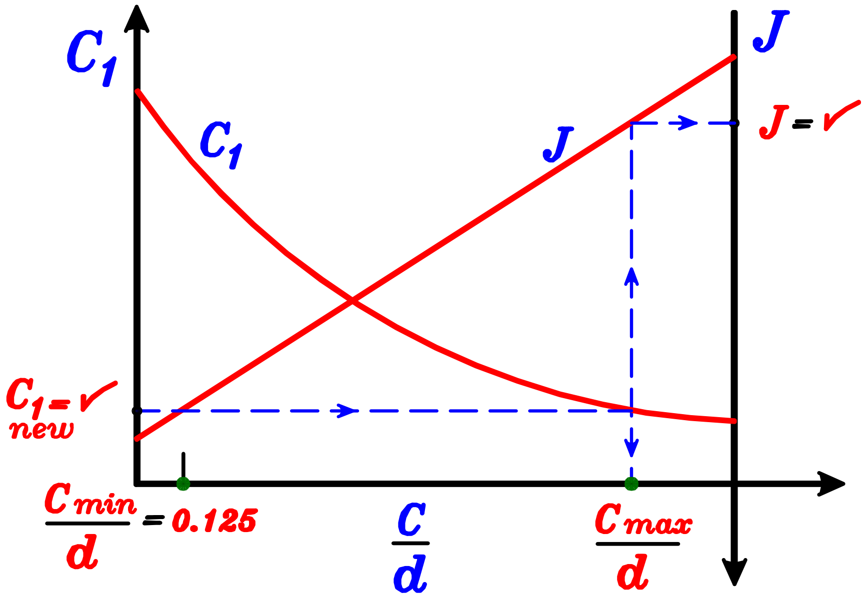
ⓐ Increase Dimensions. (Get d_{new})

- Take

$C_{1_{new}} = 2.78$ st. 360/520

$= 2.64$ st. 240/350

Get → J



- Get $\boxed{d_{new} = C_{1_{new}} \sqrt{\dfrac{M_{U.L.}}{F_{cu}\, b}}}$, $\boxed{A_s = \dfrac{M_{U.L.}}{J\, F_y\, d}}$

ⓑ Use $A_s`$ using First Principles.

- Calculate $a_{max} = 0.8\, C_{max} = 0.8\left(\frac{2}{3}\right) C_b = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (F_y \backslash \delta_s)}\right] \cdot d$

- Get $M_{U.L._{max}} = \frac{2}{3}\, \frac{F_{cu}}{\delta_c}\, a_{max}\, b \left(d - \frac{a_{max}}{2}\right)$

- Get $\triangle M = M_{U.L.} - M_{U.L._{max.}}$

- Get $A_s`$ From $\triangle M = A_s`\, \frac{F_y}{\delta_s}\,(d - d`)$

- Get $A_s = \mu_{max.}\, b\, d + A_s`$

$\mu_{max.}$ From Code Page (4–6) Table (4–1)

① IF $\frac{A_s`}{A_s} \leqslant 0.40$ $\therefore$ o.k.

② IF $\frac{A_s`}{A_s} > 0.40$ We have to Increase Dimensions.

Example.

$F_{cu} = 30\ N\backslash mm^2$ st. 360/520 $M_{U.L.} = 300\ kN.m$

$b = 250\ mm$ $d = 600\ mm$

$= 500\ mm$

$= 1000\ mm$

Req.

Get A_s , $A_{s'}$ IF Required.

Solution.

① $d = 600\ mm$

$$\because d = C_1 \sqrt{\frac{M_{U.L.}}{F_{cu}\ b}} \qquad \therefore 600 = C_1 \sqrt{\frac{300 * 10^6}{30 * 250}} \longrightarrow C_1 = 3.0$$

– From Charts. $C_1 = 3.0 \longrightarrow \frac{C}{d} = 0.3625 \longrightarrow J = 0.743$

$$\therefore A_s = \frac{M_{U.L.}}{J\ F_y\ d} = \frac{300 * 10^6}{0.743 * 360 * 600} = 1869\ mm^2$$

– Check $A_{s_{min.}}$ $A_{s_{req.}} = 1869\ mm^2$

$$\mu_{min.}\ b\ d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\ d = \left(0.225 * \frac{\sqrt{30}}{360}\right) 250 * 800 = 684.6\ mm^2$$

$\therefore A_{s_{req.}} > \mu_{min.}\ b\ d$

$\therefore$ Take $A_s = A_{s_{req.}} = 1869\ mm^2$ 5 ϕ 22

② $d = 500$ mm

$\because d = C_1 \sqrt{\dfrac{M_{U.L.}}{F_{cu}\, b}} \quad \therefore 500 = C_1 \sqrt{\dfrac{300 * 10^6}{30 * 250}} \longrightarrow C_1 = 2.5$

$\therefore C_1 = 2.5 < 2.78$

$\therefore \dfrac{C}{d} > \dfrac{C_{max.}}{d}$ $\therefore$ We have to increase Dimensions OR use A_s' using First Principles.

ⓐ Increase Dimensions. (Get d_{new})

- Take $C_{1_{new}} = 2.78$, $J = 0.717$

$$d_{new} = C_{1_{new}} \sqrt{\frac{M_{U.L.}}{F_{cu}\, b}} = 2.78 \sqrt{\frac{300 * 10^6}{30 * 250}} = 556 \text{ mm}$$

Take $\boxed{d_{new} = 600 \text{ mm}}$, $\boxed{t_{new} = 650 \text{ mm}}$

$$\therefore A_s = \frac{M_{U.L.}}{J\, F_y\, d} = \frac{300 * 10^6}{0.717 * 360 * 556} = 2090.38 \text{ mm}^2$$

- Check $A_{s_{min.}}$ $\quad A_{s_{req.}} = 2096.2 \text{ mm}^2$

$$\mu_{min.}\, b\, d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\, d = \left(0.225 * \frac{\sqrt{30}}{360}\right) 250 * 600 = 513.5 \text{ mm}^2$$

$\therefore A_{s_{req.}} > \mu_{min.}\, b\, d$

$\therefore$ Take $A_s = A_{s_{req.}} = 2096.2 \text{ mm}^2$ $\quad 6 \phi 22$

ⓑ Use A_{s}' using First Principles.

$$a_{max} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (F_y \backslash \delta_s)}\right] * d = 0.35\ d = 0.35 * 500 = 175\ mm$$

$$M_{U.L._{max}} = \frac{2}{3}\frac{F_{cu}}{\delta_c} a_{max} b \left(d - \frac{a_{max}}{2}\right) = \frac{2}{3}\left(\frac{30}{1.5}\right)(175)(250)\left(500 - \frac{175}{2}\right) = 240625000\ N.mm$$

$$= 240.625\ kN.m$$

$\because M_{U.L.} > M_{U.L._{max.}}$ $\therefore$ We need to use A_{s}'

- Get $\Delta M = M_{U.L.} - M_{U.L._{max.}} = 300 - 240.625 = 59.375\ kN.m$

- Get A_{s}' From $\Delta M = A_{s}' \dfrac{F_y}{\delta_s}(d - d')$

$$\therefore 59.375 * 10^{6} = A_{s}'\left(\frac{360}{1.15}\right)(500 - 50) \longrightarrow A_{s}' = 421.5\ mm^2$$

4 ϕ 12

$\mu_{max.} = 5 * 10^{-4} F_{cu} = 5 * 10^{-4} * 30 = 0.015$ From Code Page (4–6) Table (4–1)

$$\therefore A_s = \mu_{max.} b\, d + A_{s}' = (0.015)(250)(500) + 421.5 = 2296.5\ mm^2$$

- Check $\dfrac{A_{s}'}{A_s} = \dfrac{421.5}{2296.5} = 0.183 < 0.40$ $\therefore$ o.k.

7 ϕ 22

③ $\underline{\underline{d = 1000\ mm}}$

$$\because\ d = C_1 \sqrt{\frac{M_{U.L.}}{F_{cu}\ b}} \quad \therefore\ 1000 = C_1 \sqrt{\frac{300*10^6}{30\ *250}} \longrightarrow C_1 = 5.0$$

$$C_1 > 4.85 \xrightarrow{Take} J = 0.826$$

$$\therefore\ A_s = \frac{M_{U.L.}}{J\ F_y\ d} = \frac{300*10^6}{0.826*360\ *1000} = 1008.8\ mm^2$$

– $\underline{\text{Check } A_{s\,min.}}$ $\quad A_{s\,req.} = 1008.8\ mm^2$

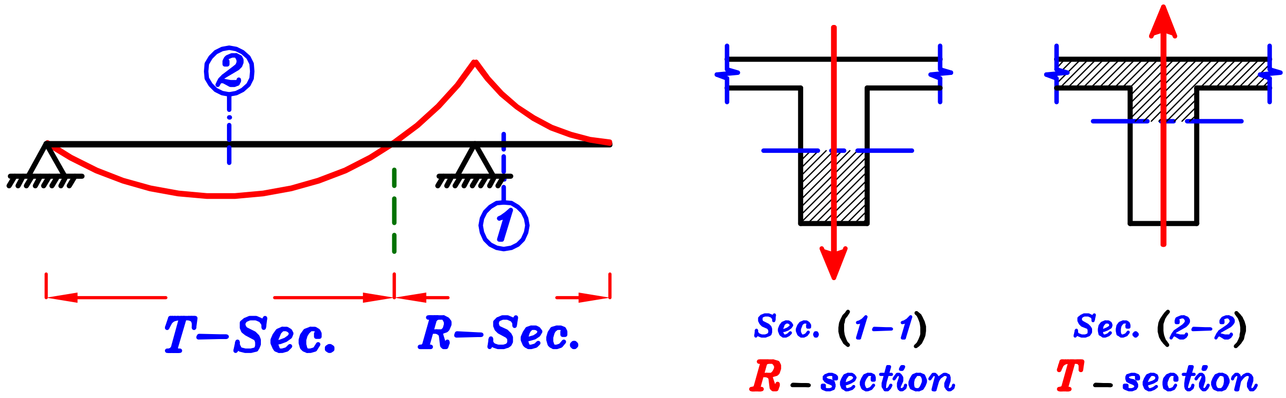
$$\mu_{min.}\ b\ d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\ d = \left(0.225 * \frac{\sqrt{30}}{360}\right) 250 * 1000 = 855.8\ mm^2$$

$$\therefore\ A_{s_{req.}} > \mu_{min.}\ b\ d$$

$$\therefore\ \text{Take } A_s = A_{s_{req.}} = 1008.8\ mm^2 \quad 3\ \phi\ 22$$

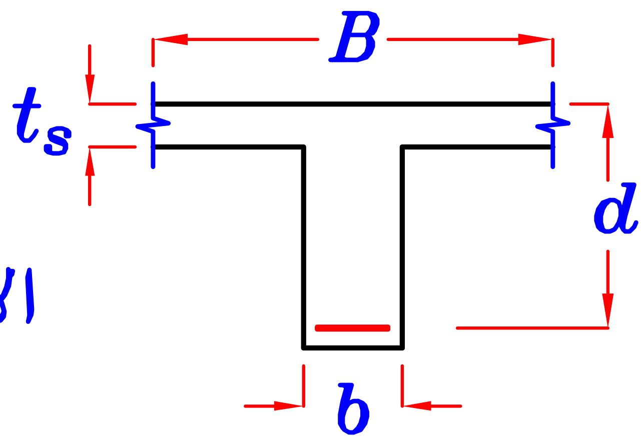
Design of T-Section & L-Section using First Principles

* T-Section. كمره وسطيه (أى أن البلاطة من الإتجاهين)

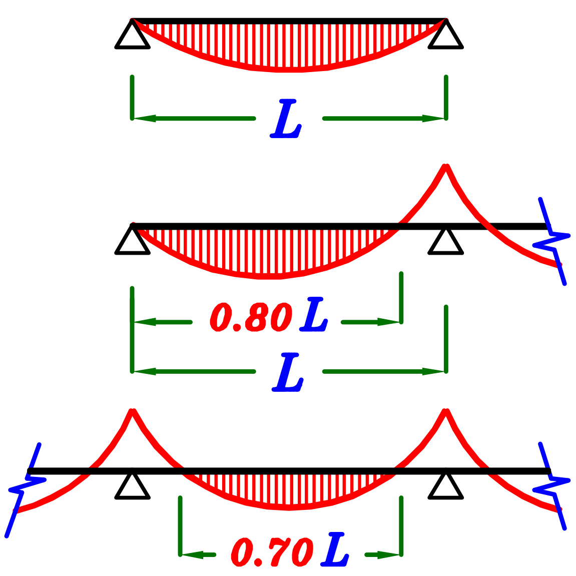


Effective Width. (B)

$$B = \begin{Bmatrix} C.L_{slab} \rightarrow C.L_{slab} \\ 16\,t_s + b \\ K\,\frac{L}{5} + b \end{Bmatrix} \text{ الأقل}$$



بعد حساب الثلاث قيم لل B نأخذ أقل قيمه منهم لانه more safe فى التصميم ان نعتبر القطاع اضعف .



$K = 1.0$

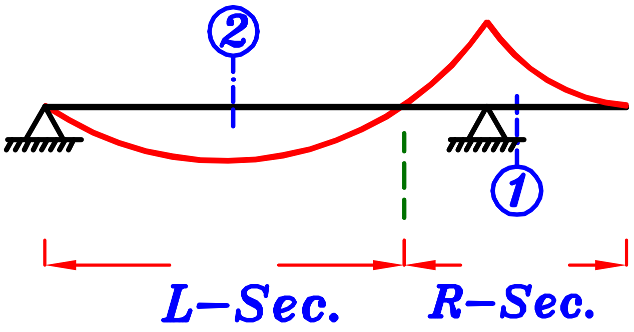
$K = 0.80$

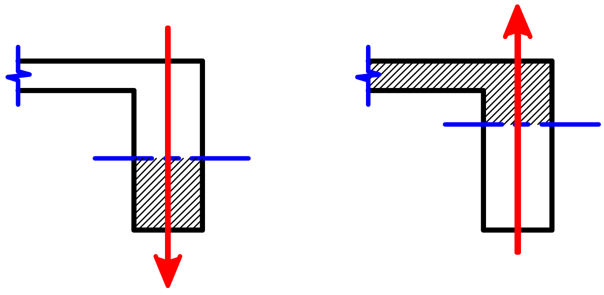
$K = 0.70$

L هو طول الكمره الحقيقى span من ال support الى ال support

K هو Factor بحيث تكون قيمه K*L هو البحر المعلق للكمره أى هو طول الكمره الذى كل القطاعات فيه نوعها T-Sec.

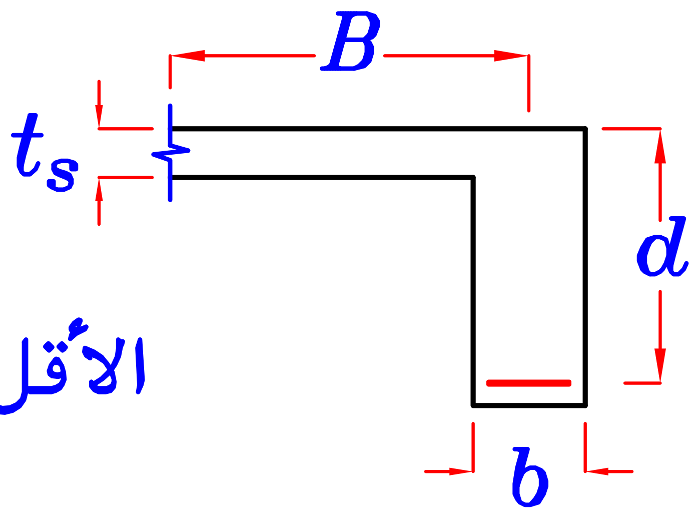
* L–Sections. (أى أن البلاطة من جهة واحده) كمره طرفية



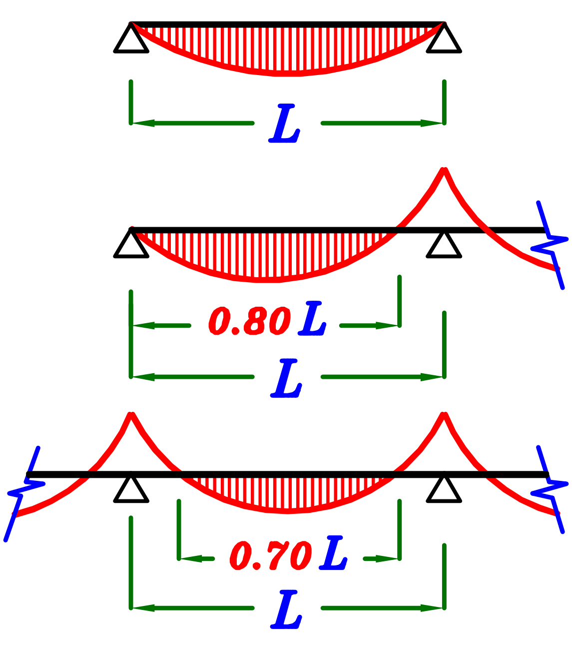


Effective Width. (B)

$$B = \left\{ \begin{array}{l} C.L_{beam} \rightarrow C.L_{slab} \\ 6\,t_s + b \\ K\,\dfrac{L}{10} + b \end{array} \right\} \text{الأقل}$$



بعد حساب الثلاث قيم لل B نأخذ أقل قيمه منهم لانه *more safe* فى التصميم ان نعتبر القطاع اضعف .



$K = 1.0$

$K = 0.80$

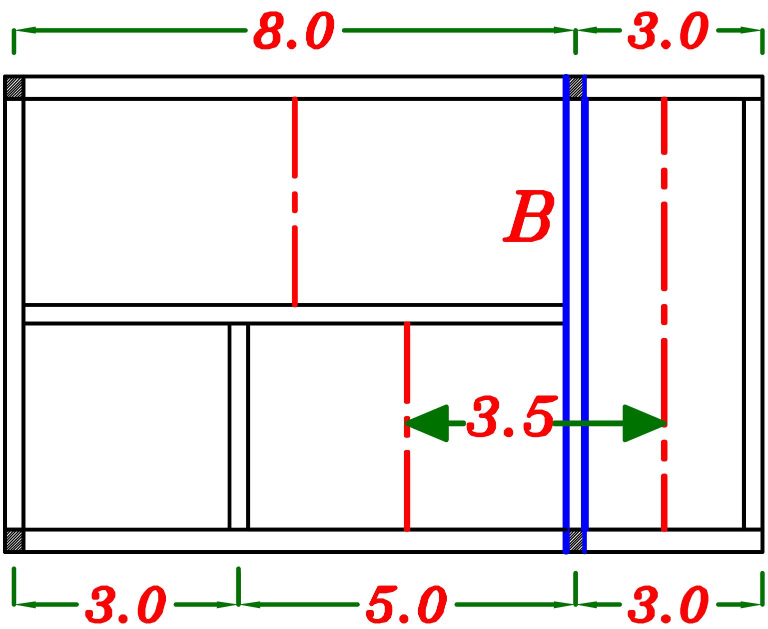
$K = 0.70$

L هو طول الكمره الحقيقى *span* من ال *support* الى ال *support*

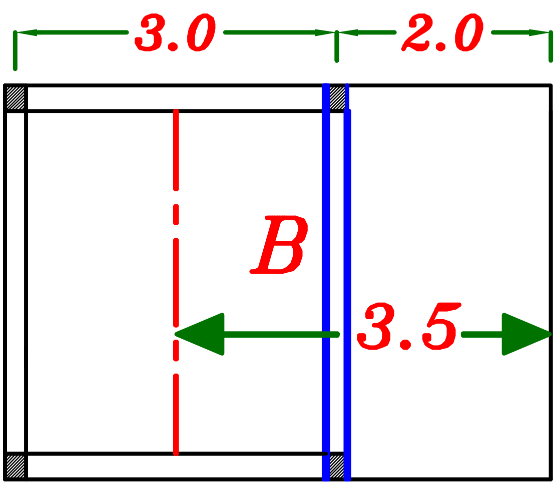
K هو *Factor* بحيث تكون قيمه $K*L$ هو البحر المعلق للكمره أى هو طول الكمره الذى كل القطاعات فيه نوعها *L–Sec.*

Special Cases of Calulating B

عند حساب قيمه ال B و وجدنا انه من الممكن ان تكون هناك عده قيم لل B
نأخذ أقل قيمه منهم لانه more safe فى التصميم ان نعتبر القطاع اضعف .



$$\underset{slab}{C.L.}-\underset{slab}{C.L.}=\frac{3.0}{2}+\frac{5.0}{2}$$
$$=4.0\ m$$



اذا وجدت بلاطه Cantilever

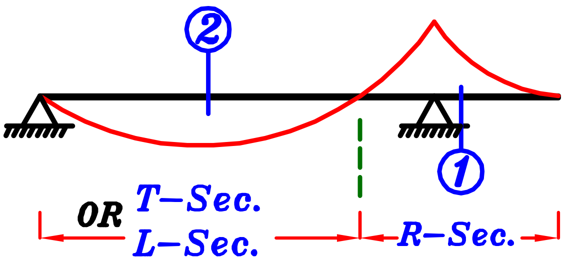
عند حساب قيمه $\underset{slab}{C.L.}-\underset{slab}{C.L.}$

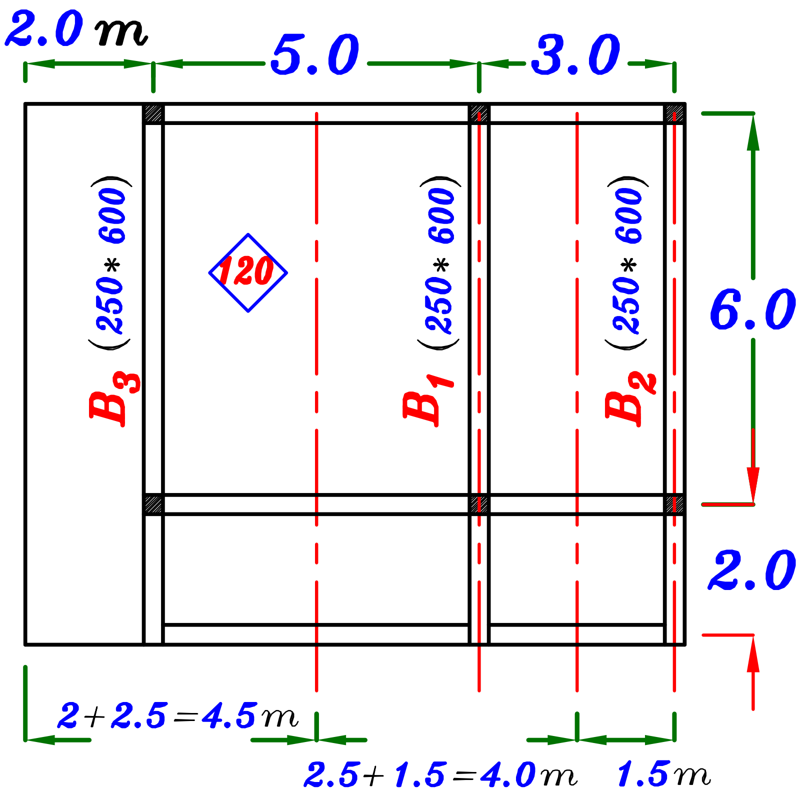
يتم أخذ طول البلاطه ال Cantilever

$$\underset{slab}{C.L.}-\underset{slab}{C.L.}=\frac{3.0}{2}+2.0$$
$$=3.50\ m$$

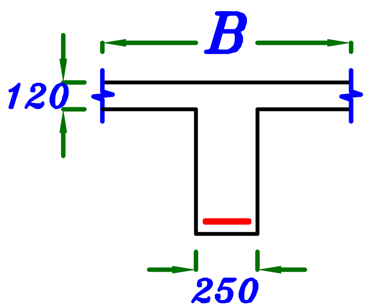
Example.

Get B For B_1 , B_2 , B_3



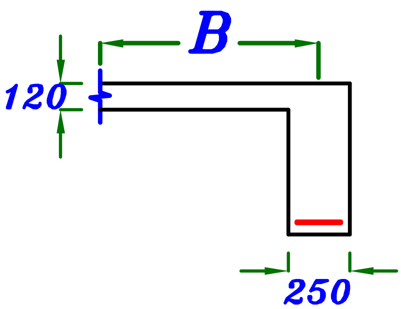


B_1 كمره وسطيه



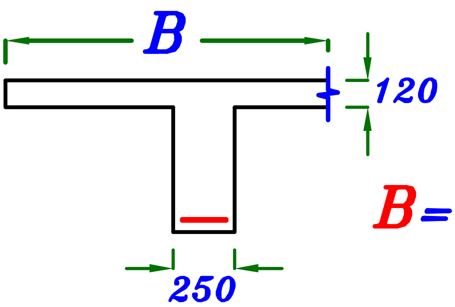
$$B = \left\{ \begin{array}{l} C.L.-C.L. = 2.5+1.5 = 4.0\ m = 4000\ mm \\ 16\ t_s + b = 16 * 120 + 250 = 2170\ mm \\ K\dfrac{L}{5} + b = 0.8 * \dfrac{6000}{5} + 250 = 1210\ mm \end{array} \right\} = 1210\ mm$$

B_2 كمره طرفيه



$$B = \left\{ \begin{array}{l} C.L.-C.L. = 1.5\ m = 1500\ mm \\ 6\ t_s + b = 6 * 120 + 250 = 970\ mm \\ K\dfrac{L}{10} + b = 0.8 * \dfrac{6000}{10} + 250 = 730\ mm \end{array} \right\} = 730\ mm$$

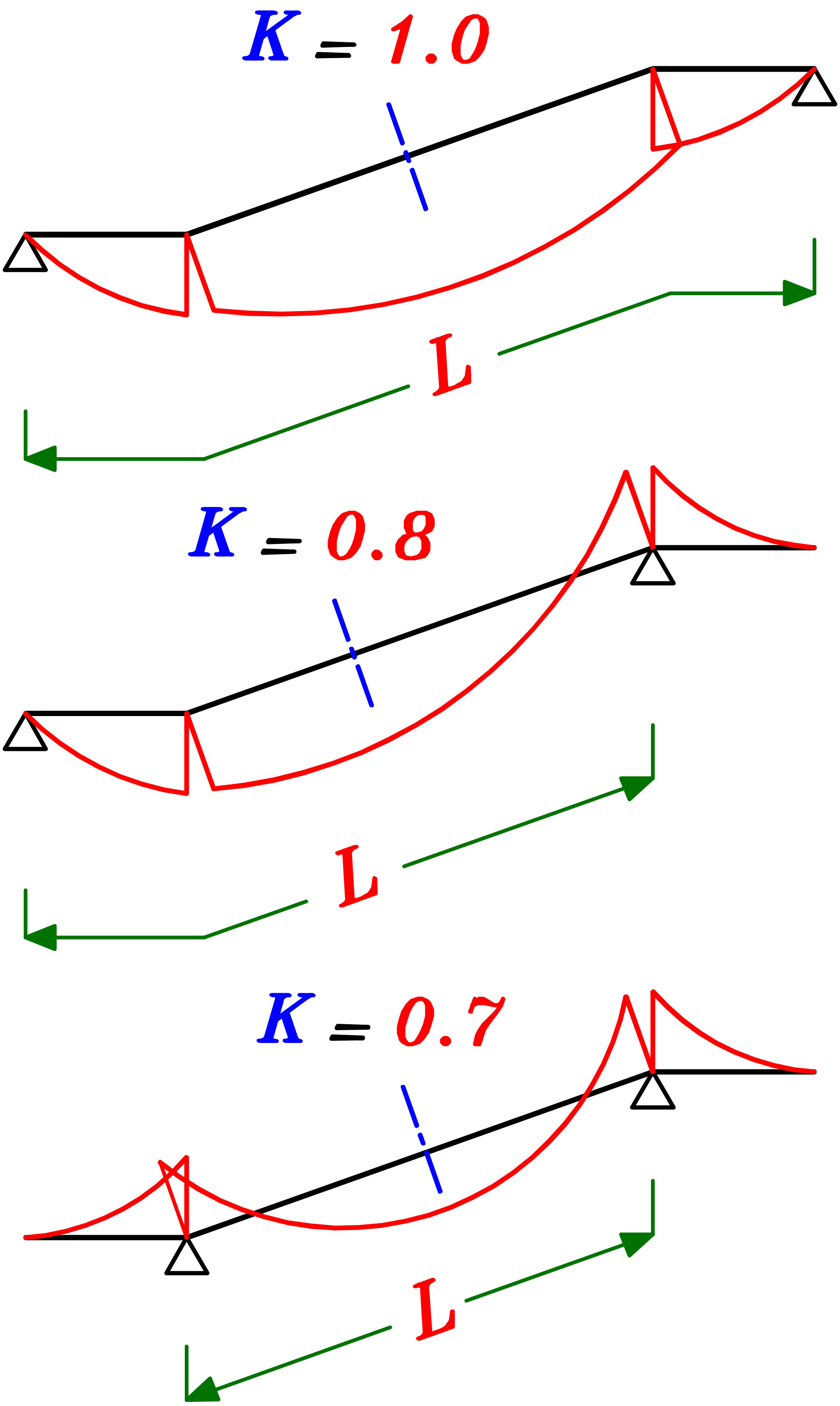
B_3 كمره وسطيه



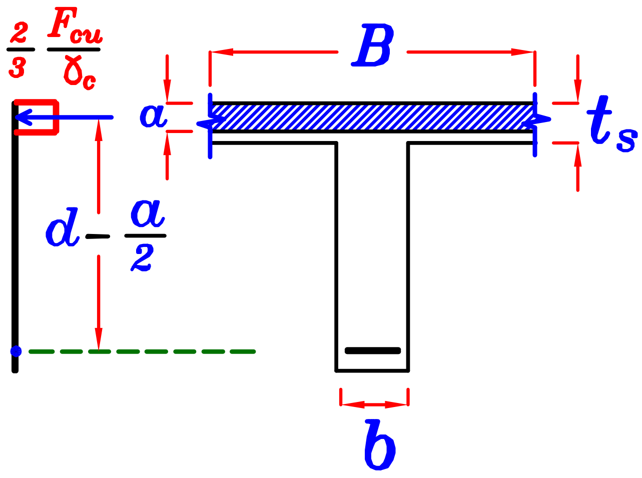
$$B = \left\{ \begin{array}{l} C.L.-C.L. = 2.5+2.0 = 4.5\ m = 4500\ mm \\ 16\ t_s + b = 16 * 120 + 250 = 2170\ mm \\ K\dfrac{L}{5} + b = 0.8 * \dfrac{6000}{5} + 250 = 1210\ mm \end{array} \right\} = 1210\ mm$$

عند وجود كمرات بها اجزاء افقيه و اجزاء مائله

يتم تحديد طول L هو طول **span** الكمره الحقيقى من ال **support** الى ال **support**



Steps of Design.



① Assume that $a \leq t_s$

i.e.

the Sec. is working as R–Sec.

But with width B

② IF d is not given.

Take the value of $C_1 = (5.0 \longrightarrow 7.0)$

$$- \; d = C_1 \sqrt{\frac{M_{U.L.}}{F_{cu}\, B}} = \checkmark$$ تقرب لأقرب ٥٠ مم بالزياده

$$- \quad A_s = \frac{M_{U.L.}}{0.826\, F_y\, d}$$ قبل التقريب

$$- \; \text{Check } A_{s_{min.}} = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\, d$$ ال b الصغيره

③ IF d is given.

– Get C_1 From $d = C_1 \sqrt{\dfrac{M_{U.L.}}{F_{cu}\, B}} \longrightarrow C_1 = \checkmark$

– From C_1 Get J, $\dfrac{c}{d}$ From Charts.

– IF $C_1 \geq 4.85 \longrightarrow \dfrac{c}{d} \leq \dfrac{c_{min.}}{d} \xrightarrow{\text{Take}} J = 0.826$

$$\therefore \; \boxed{A_s = \frac{M_{U.L.}}{0.826\, F_y\, d}}$$ and check $A_{s_{min}}$

- IF $2.78 \leqslant C_1 < 4.85 \longrightarrow \frac{C_{min.}}{d} \leqslant \frac{C}{d} < \frac{C_{max.}}{d} \xrightarrow{Get} J$

$$\therefore \boxed{A_S = \frac{M_{U.L.}}{J\ F_y\ d}}$$ and check $A_{S_{min}}$

- IF $C_1 < 2.78$ st. 360/520 & st. 400/600
$C_1 < 2.64$ st. 240/350

We have to increase Dimensions

Increase Dimensions. (Get d_{new})

- Take $C_{1_{new}} = 2.78$ st. 360/520 & st. 400/600 $\xrightarrow{Get} J$

$C_{1_{new}} = 2.64$ st. 240/350

- Get $\boxed{d_{new} = C_{1_{new}} \sqrt{\frac{M_{U.L.}}{F_{cu}\ B}}}$, $\boxed{A_S = \frac{M_{U.L.}}{J\ F_y\ d}}$

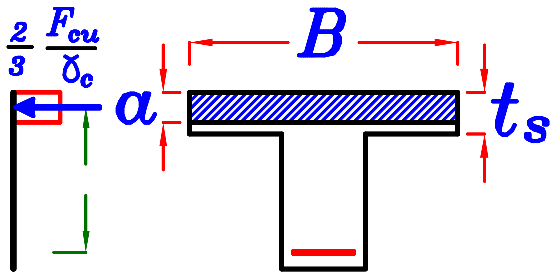
ملحوظه هامه

لا يوجد A_s` فى ال T-sec.

ملحوظه هامه .

يتم تصميم القطاعات $T-Sec.$ & $L-Sec.$ على أنها $R-Sec.$ و لكن بعرض مختلف

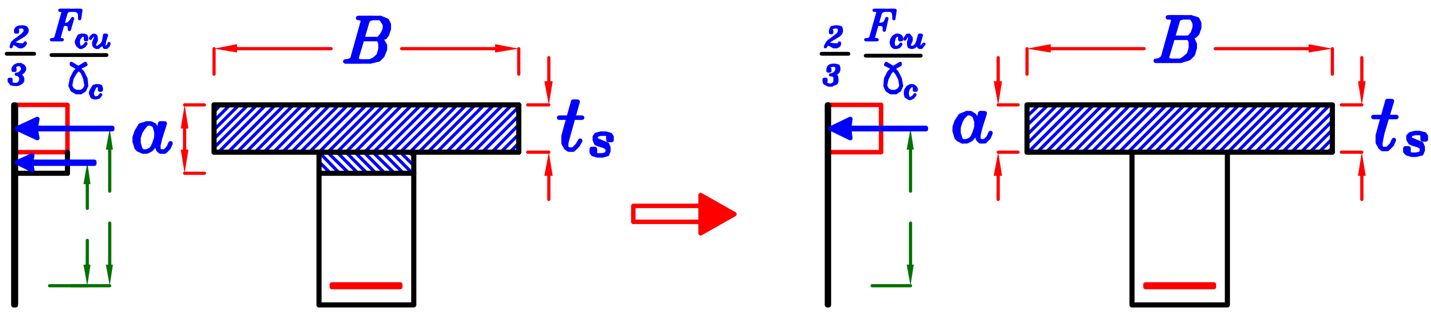
على اساس انه فى اغلب الاحيان ستكون $a \leqslant t_s$



$T-Sec.$

و حتى اذا كانت $a > t_s$ ستكون اكبر منها بقيمه صغيره

لذلك من الممكن ان نعتبر ان $a = t_s$



$T-Sec.$ $T-Sec.$

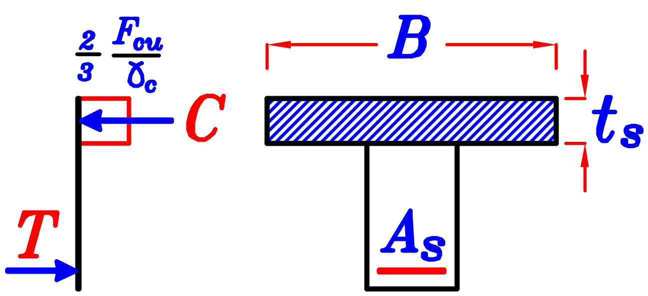
عند تصميم القطاعات $T-Sec.$ & $L-Sec.$ و كانت قيمه $C_1 > 4.85$

اى ان قيمه $a < a_{min}$ لذا نأخذ قيمه $J = 0.826$ حتى تصبح قيمه $a = a_{min}$

لكن فى حاله ما اذا اخذنا قيمه $a = a_{min} = 0.1\, d$ و كانت اكبر من ال t_s

فى هذه الحاله سنأخذ قيمه $a = t_s$ و بالتالى لن نستطيع حساب كميه الحديد

عن طريق اخذ قيمه $J = 0.826$ بل سنضطر حسابها عن طريق $C = T$



$$C = T$$

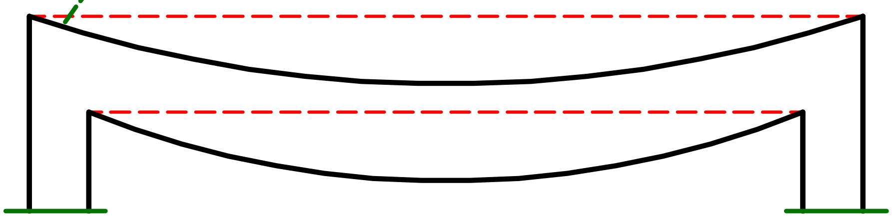
$$\frac{2}{3}\frac{F_{cu}}{\gamma_c}\, t_s\, B = A_s * \frac{F_y}{\gamma_s} \longrightarrow \boxed{A_s}$$

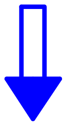
فى هذا الملف لن نحسب قيمه a لذا لن نقارنها بقيمه a_{min}

Drawing Bending moment For Beams.

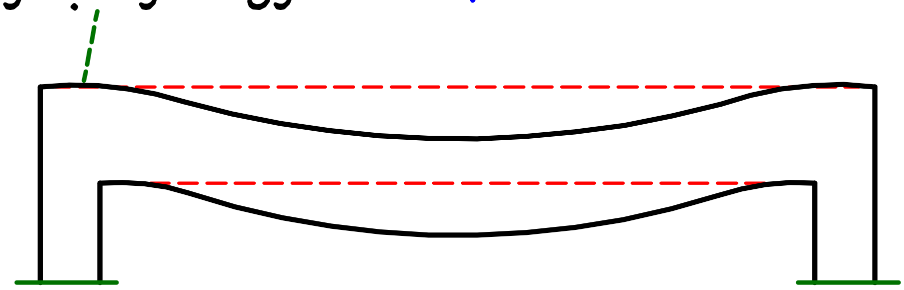
① Simple Beam.

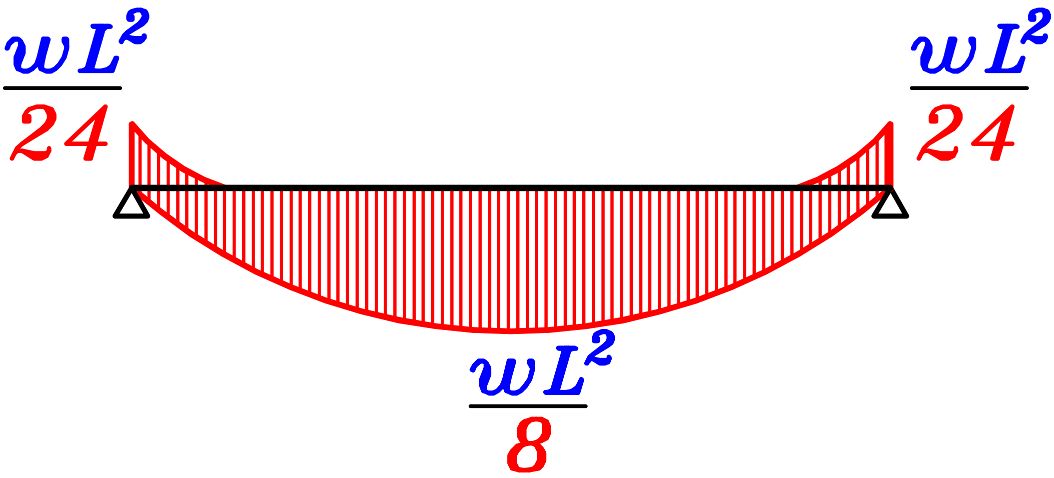
لن يحدث ***deflection*** للكمره
فوق العمود مباشره





سيحدث ***tension*** للخرسانه العلويه
فوق العمود مباشره





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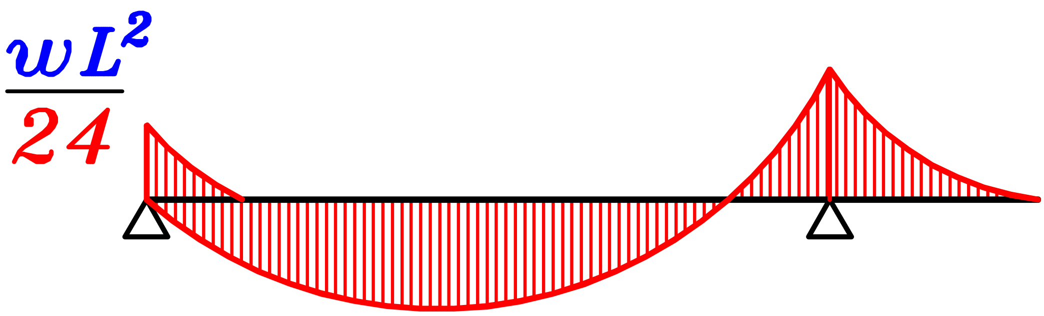
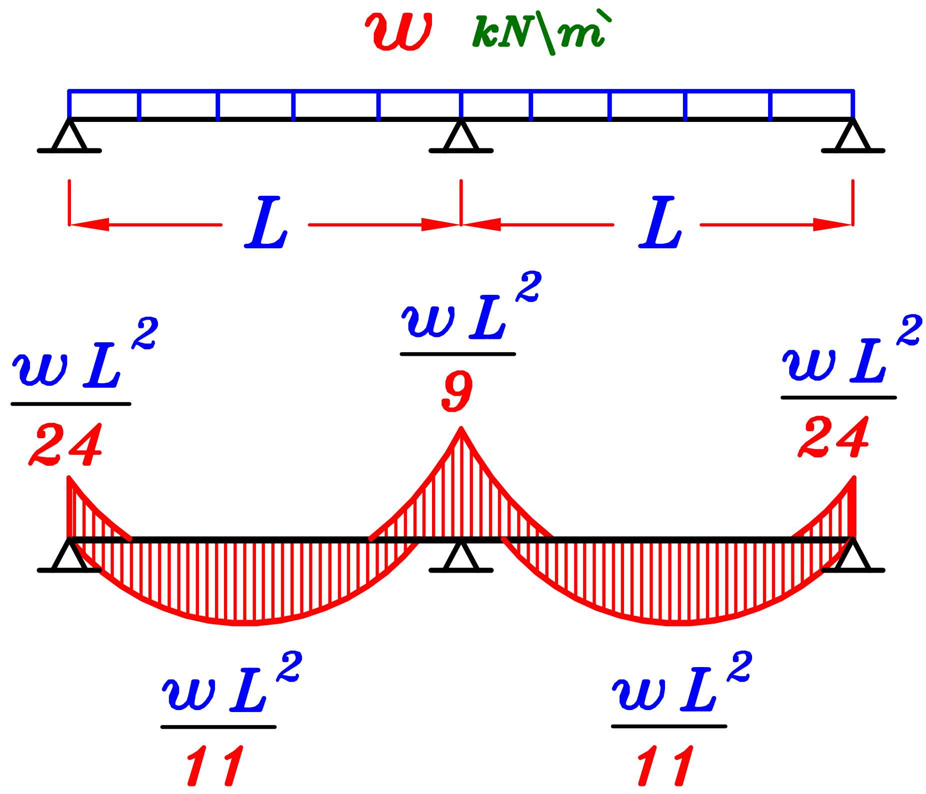
② Beam with Cantilever.

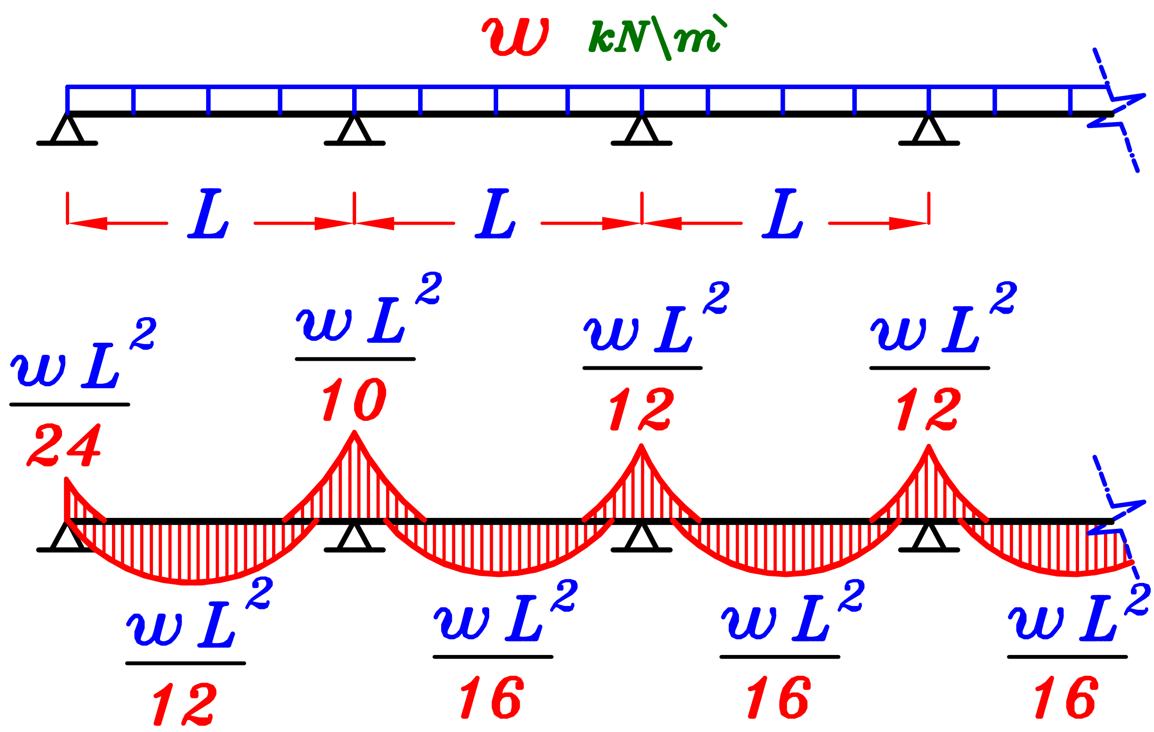


③ Continuous Beam with 2 spans.



B.M.D.

④ Continuous Beam with more than 2 spans.



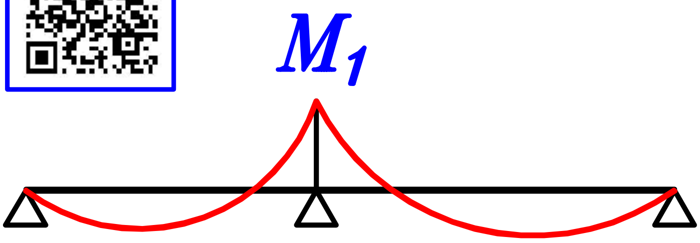
B.M.D.

ملحوظه لا نعمل حالات تحميل للكمرات الـ Continuous و لكن نضع عليها T.L.

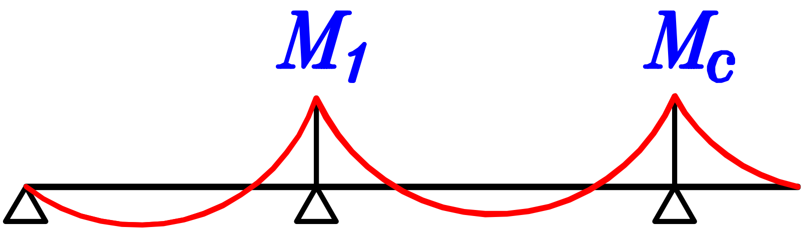
لان قيم الـ max-max محفوظه على أساس أن قيمه w هى T.L.

فى حاله البحور أو الاحمال غير متساويه و الفرق بينهم أكبر من ٢٠ ٪
نضطر لحل الشريحه بأستخدام ***3 – moment equations***

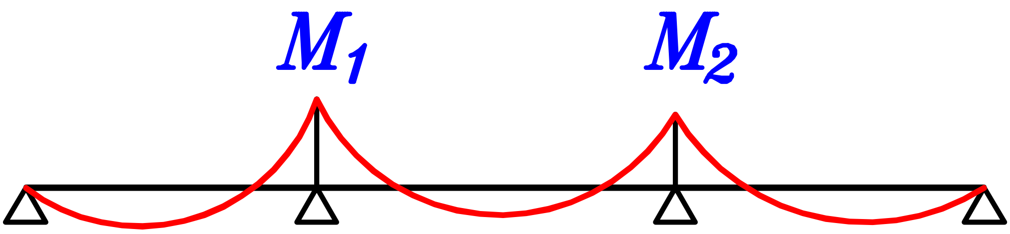
أولا نحدد عدد المجاهيل لنحدد عدد المعادلات .



مجهول واحد
اذا نحتاج معادله واحده
معادله ل M_1 فقط



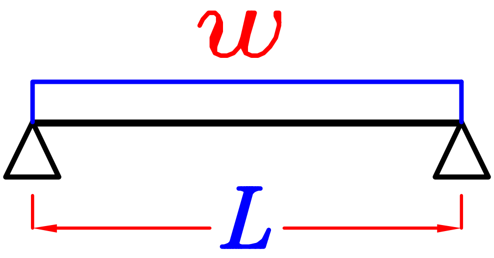
مجهول واحد لان M_c معروفه
اذا نحتاج معادله واحده
معادله ل M_1 فقط



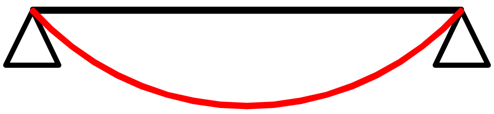
مجهولان
اذا نحتاج معادلتين
معادله ل M_1 و معادله ل M_2
نحل معادلتين فى مجهولين و نحسب قيمه كلا من M_1 و M_2

To Calculate the Elastic Reaction.

For Distributed Load only.

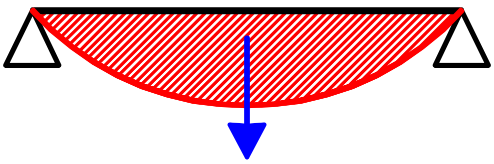


B.M.D.



$$M = \frac{wL^2}{8}$$

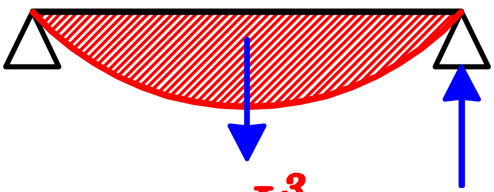
Area



Elastic weight = area of parabola

$$\text{Elastic weight} = \frac{2}{3} * M * L$$

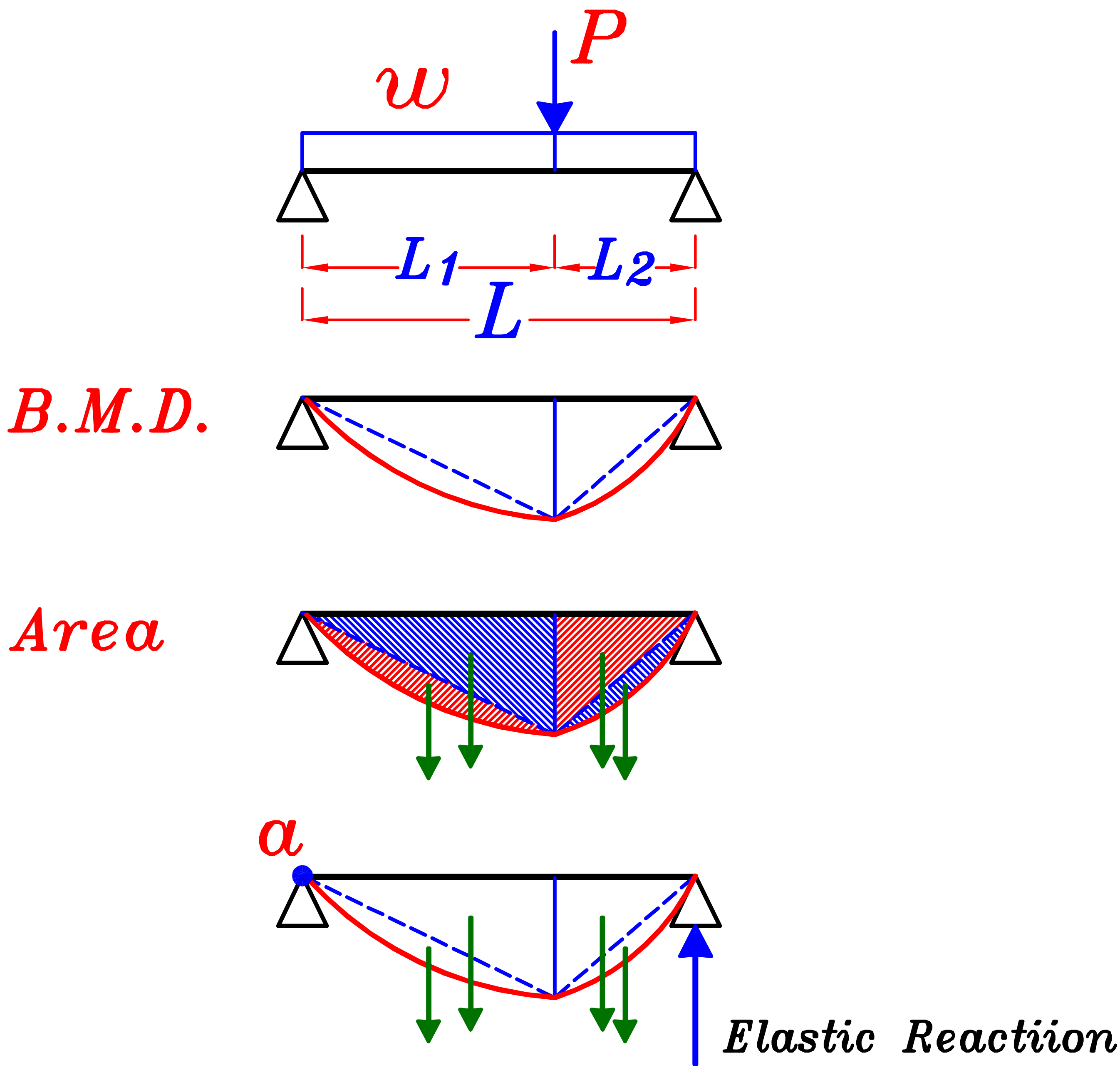
$$\text{Elastic weight} = \frac{2}{3} * \frac{wL^2}{8} * L = \frac{wL^3}{12}$$



$$\text{Elastic weight} = \frac{wL^3}{12} \qquad \text{Elastic Reaction} = \frac{wL^3}{24}$$

$$\boxed{\text{Elastic Reactions} = \frac{wL^3}{24}}$$

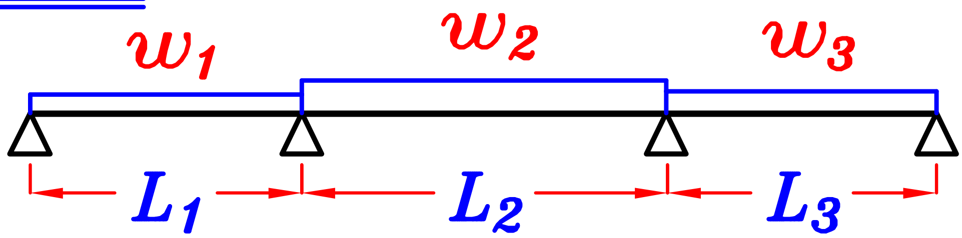
IF Distributed Load + Concentrated Load

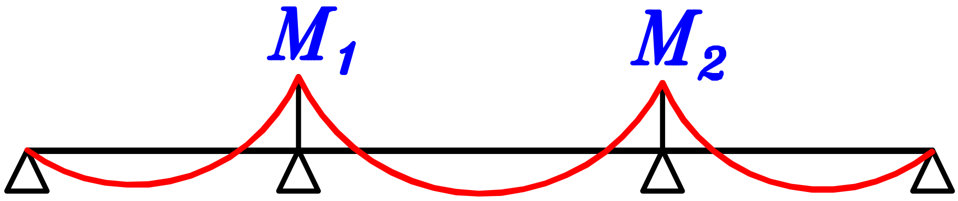


Get The Elastic Reactiion

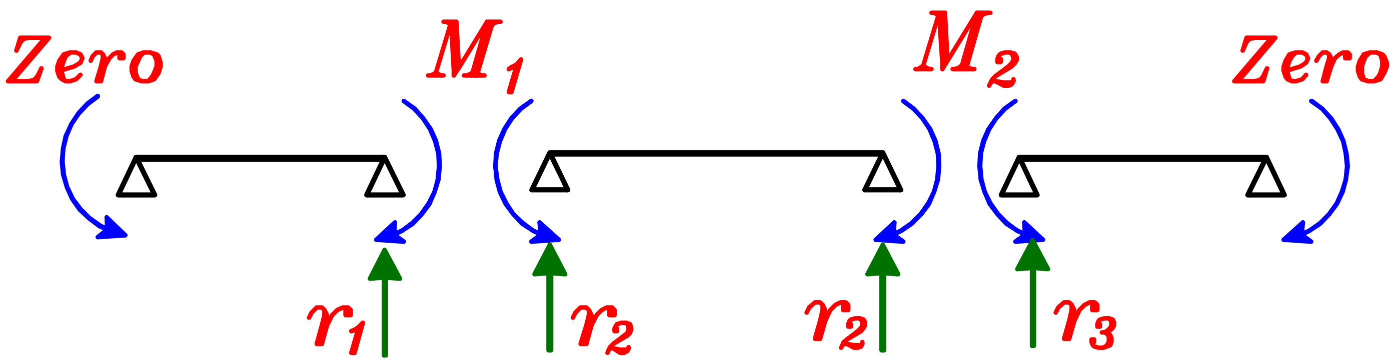
By taking moment about point $a = Zero$

Example.





مجهولان اذا نحتاج معادلتين معادله ل M_1 و معادله ل M_2



$$r_1 = \frac{w_1 L_1^3}{24} \quad , \quad r_2 = \frac{w_2 L_2^3}{24} \quad , \quad r_3 = \frac{w_3 L_3^3}{24}$$

Equation of M_1

$$Zero(L_1) + 2M_1(L_1+L_2) + M_2(L_2) = -6(r_1+r_2)$$

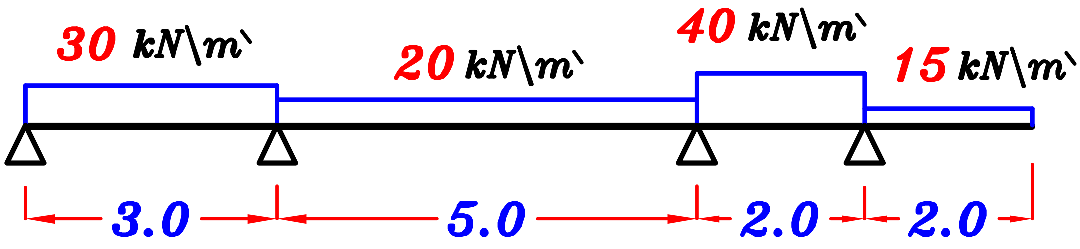
Equation of M_2

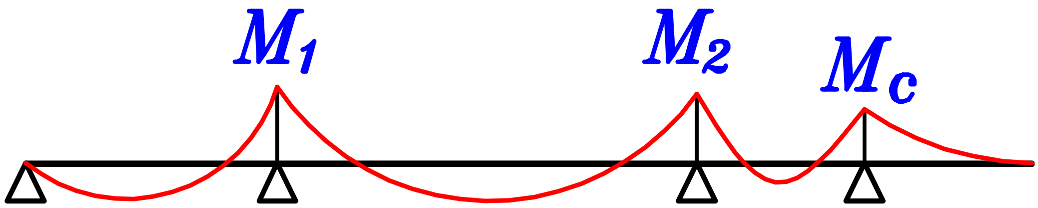
$$M_2(L_2) + 2M_2(L_2+L_3) + Zero(L_3) = -6(r_2+r_3)$$

ملحوظه اشاره ال moment تكون $(-Ve)$ اذا كان فوق ال datum

اشاره ال moment تكون $(+Ve)$ اذا كان تحت ال datum

Example.



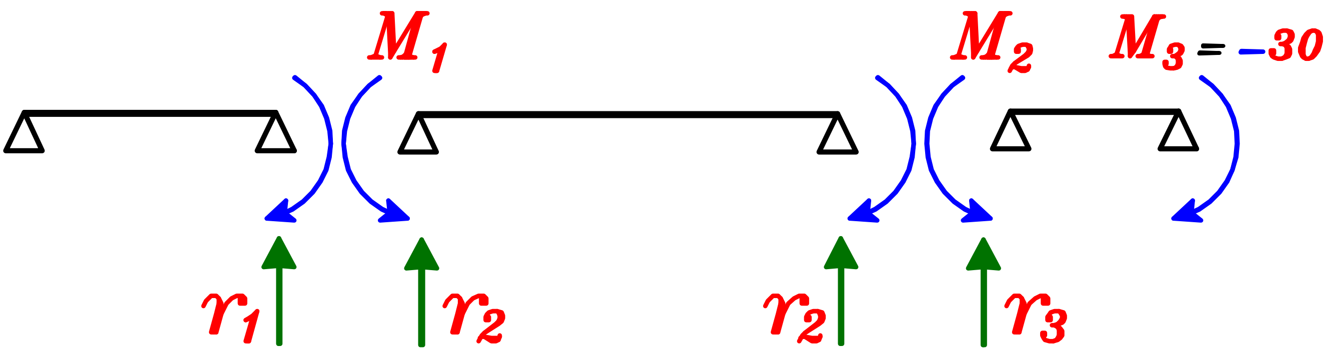


مجهولان فقط لان M_c معروفه

اذا نحتاج معادلتين معادله ل M_1 و معادله ل M_2

$$M_c = \frac{15 * 2.0^2}{2.0} = -30 \text{ kN.m}$$

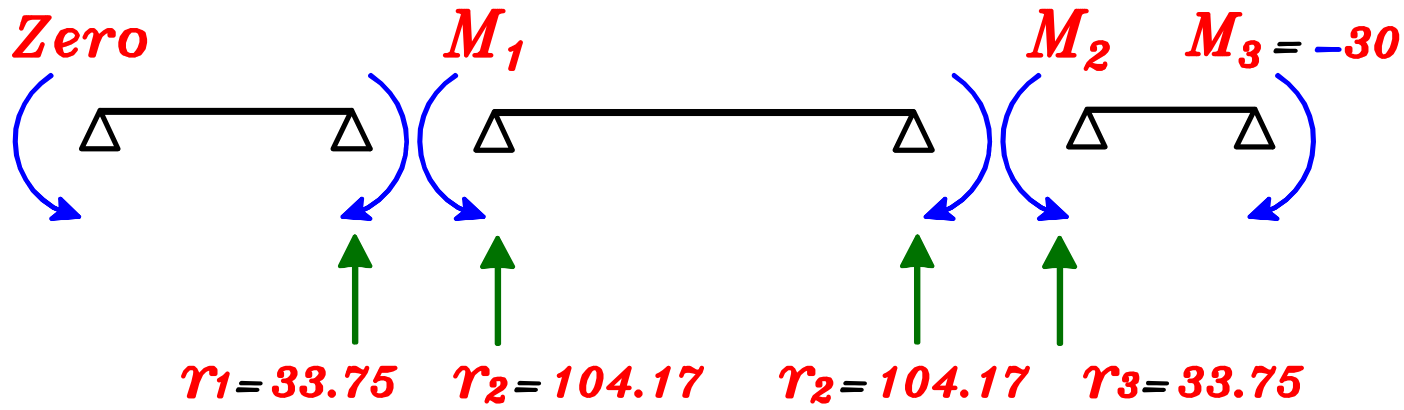
---- الاشاره سالبه لان ال moment فوق ال datum



$$r_1 = \frac{30 * 3^3}{24} = 33.75$$

$$r_2 = \frac{20 * 5^3}{24} = 104.17$$

$$r_2 = \frac{40 * 2^3}{24} = 13.34$$



Equation of M_1

$$0.0 + 2\,M_1\,(3 + 5) + M_2\,(5) = -6\,(33.75 + 104.17)$$

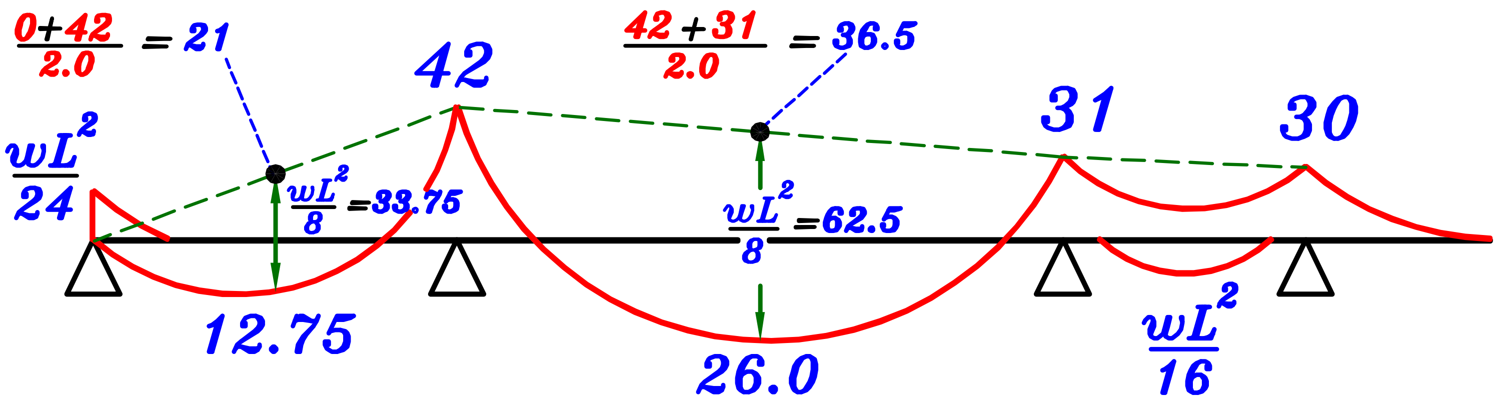
$$16\,M_1 + 5\,M_2 = -827.52 \quad \text{------} \; (1)$$

Equation of M_2

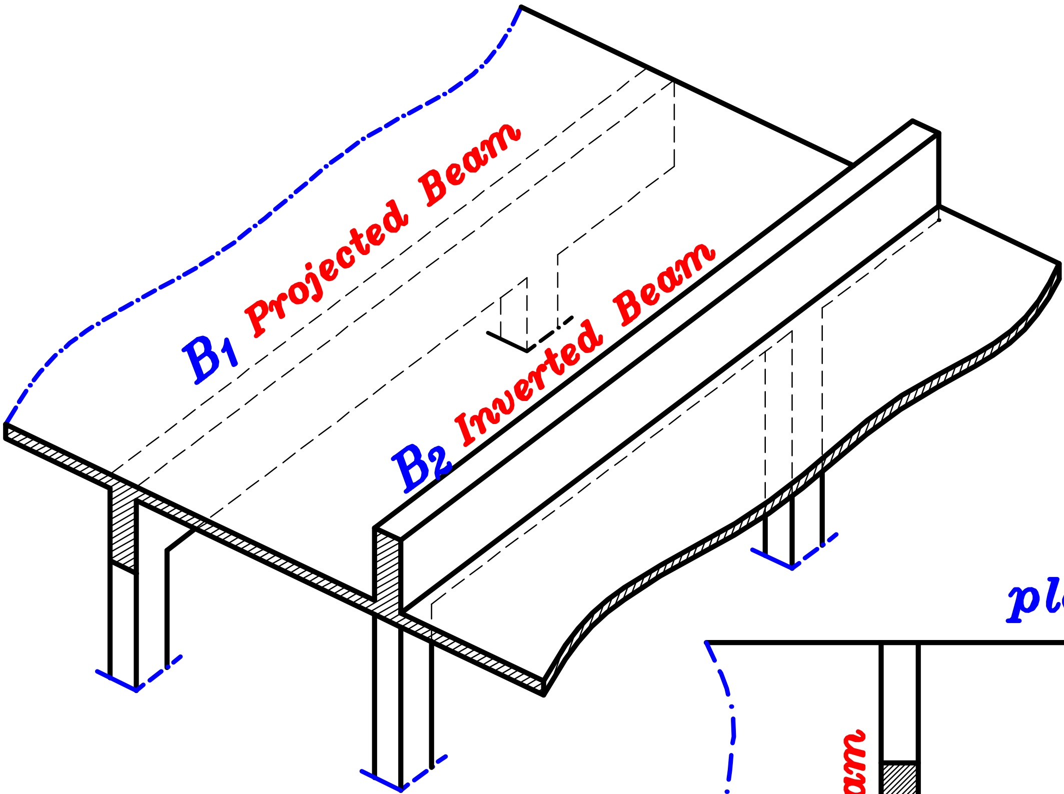
$$M_1\,(5) + 2\,M_2\,(5 + 2) + (-30)\,(2.0) = -6\,(104.17 + 13.34)$$

$$5\,M_1 + 14\,M_2 = -645.03 \quad \text{------} \; (2)$$

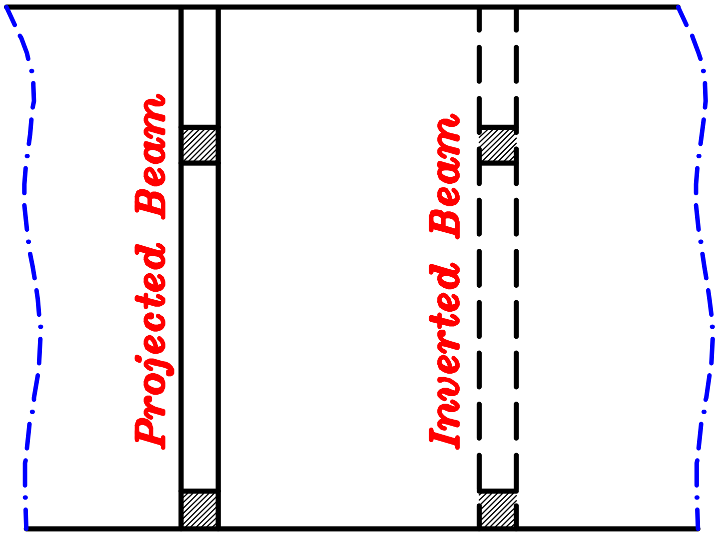
$$\boxed{M_1 = -42.0 \text{ kN.m}} \qquad \boxed{M_2 = -31.0 \text{ kN.m}}$$



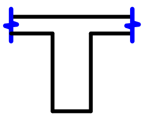
Projected & Inverted Beams.

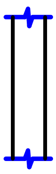


plan

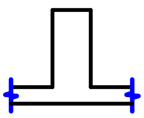


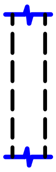
Projected Beams الكمرات الساقطه

و هى كمرات يكون منسوب البلاطه فوق الكمره حيث يكون شكل قطاع الكمره 

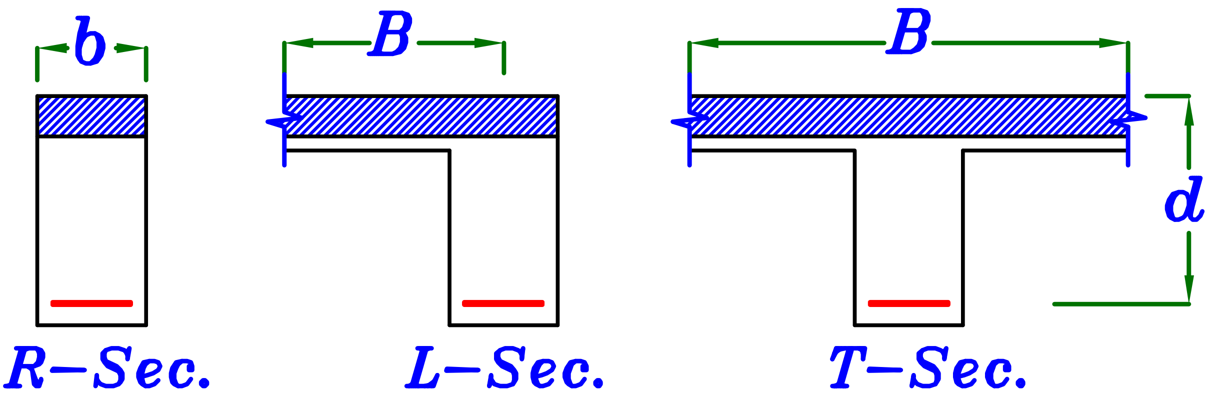
و يكون وزن البلاطه هو الذى يُحمل على الكمره ، و يرسم شكل الكمره فى ال plan 

Inverted Beams الكمرات المقلوبه

و هى كمرات يكون منسوب البلاطه أسفل الكمره حيث يكون شكل قطاع الكمره 

و يكون وزن البلاطه هو الذى يُحمل على الكمره ، و يرسم شكل الكمره فى ال plan 

Design Order. ترتيب تصميم القطاعات .



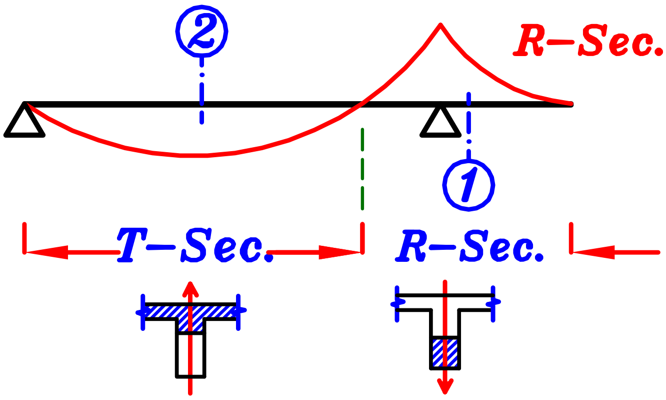
يتم تصميم القطاعات T-Sec. & L-Sec. & R-Sec. على أنها R-Sec. و لكن بعرض مختلف.

لان عرض ال B للقطاع ال T-Sec. أكبر من L-Sec. أكبر من R-Sec.

اذا القطاع ال T-Sec. أقوى من L-Sec. أقوى من R-Sec.

اذا عند التصميم سيحتاج القطاع ال R-Sec. لعمق اكبر من ال L-Sec. اكبر من ال T-Sec.

لذا اذا كانت الكمره الواحده يوجد بها مثلا T-Sec. و R-Sec.



سنبدأ بتصميم ال R-Sec. أولا و نوجد له A_s , d

ثم نأخذ قيمه ال d للـ R-Sec. على كل الكمره

ثم نصمم ال T-Sec. بنفس ال d للـ R-Sec.

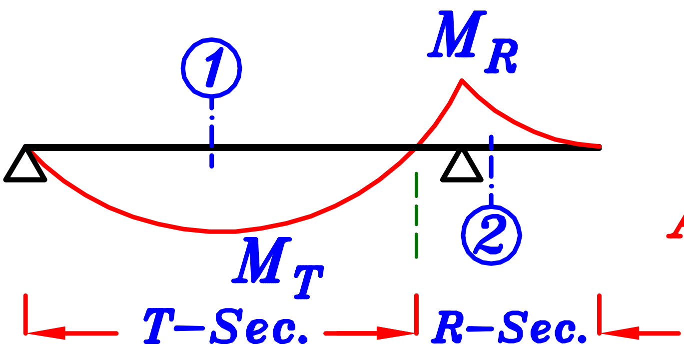
و نوجد له A_s فقط.

إذا كان فى الكمره قطاعان T-Sec. & R-Sec. نبدأ بتصمم ال R-Sec. أولاً.

إذا كان فى الكمره قطاعان L-Sec. & R-Sec. نبدأ بتصمم ال R-Sec. أولاً.

إذا كان فى الكمره قطاعان T-Sec. & L-Sec. نبدأ بتصمم ال L-Sec. أولاً.

إذا كان كل قطاعات الكمره من نفس النوع فنبدأ بتصميم القطاع الذى يؤثر عليه moment أولاً.



الحاله الوحيده التى نبدأ فيها التصميم للـ T-Sec.

قبل ال R-Sec. عندما يكون $\boxed{M_T > 2\,M_R}$

فنعمل على فرض ال d للـ T-Sec. و نوجد له A_s

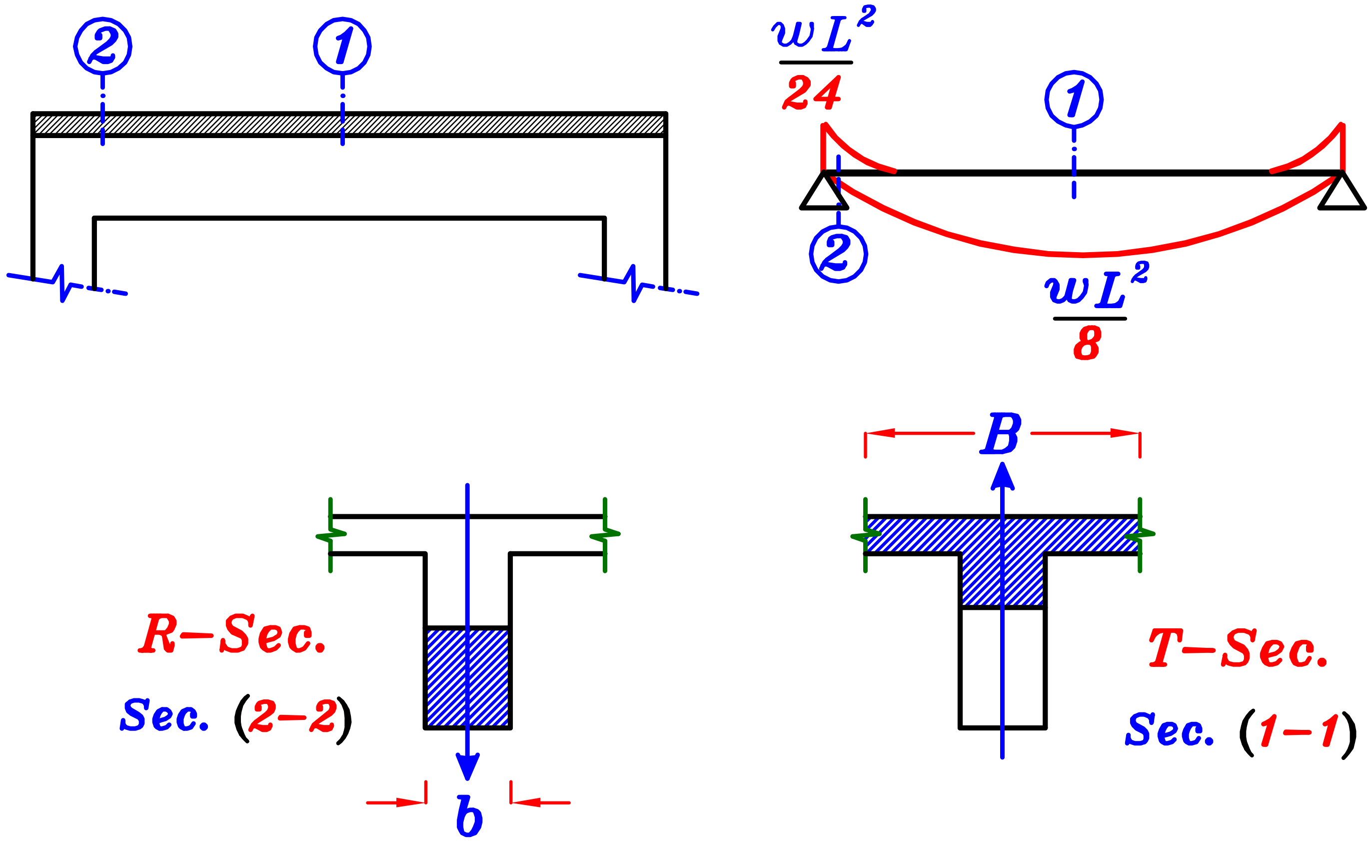
ثم نصمم ال R-Sec. بنفس ال d للـ T-Sec.

و نوجد له A_s فقط .

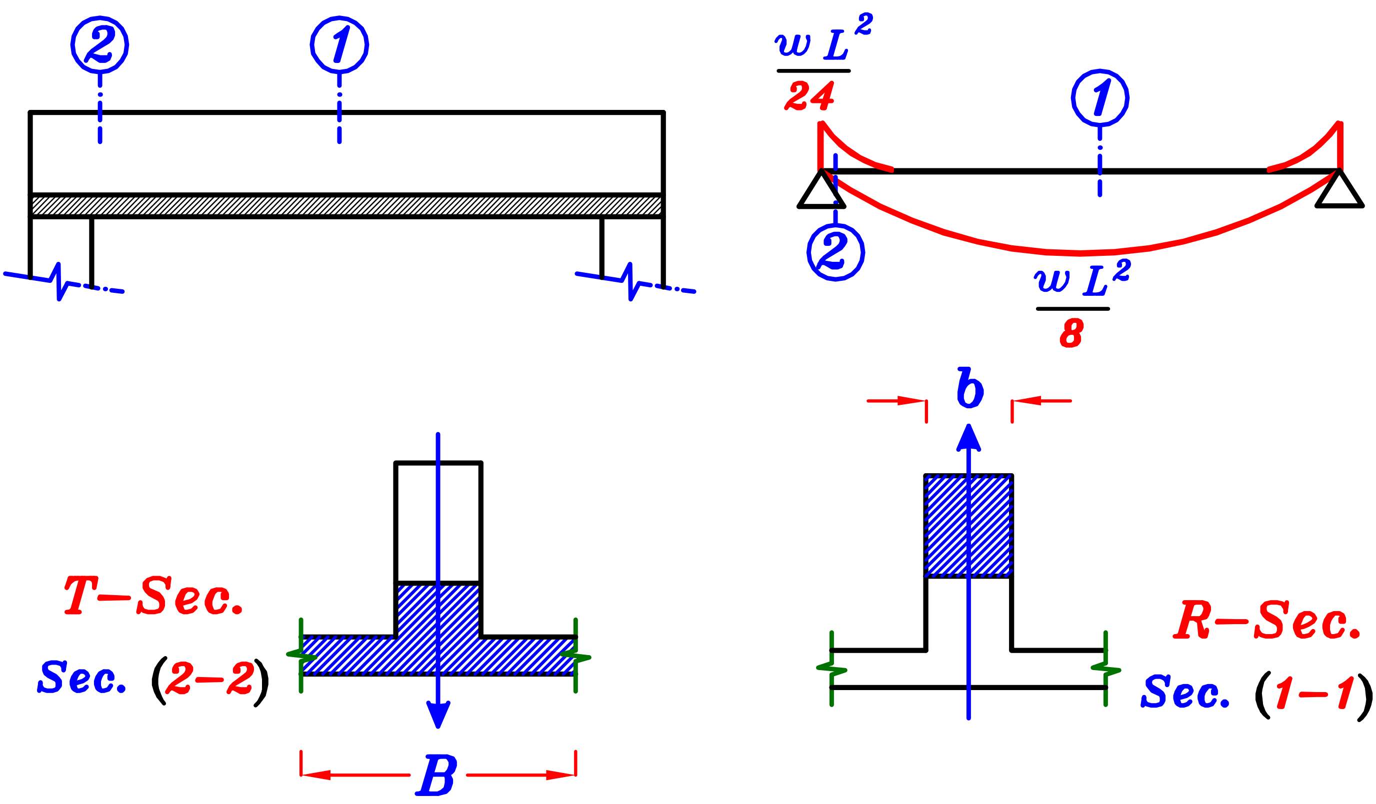
ملحوظه اذا كان d الكمره مُعطى فلن يفرق تصميم أى قطاع قبل الاخر .

الكمرات المقلوبه يكون نوع القطاع فيها عكس الكمره الساقطه

Projected Beam. كمره ساقطه

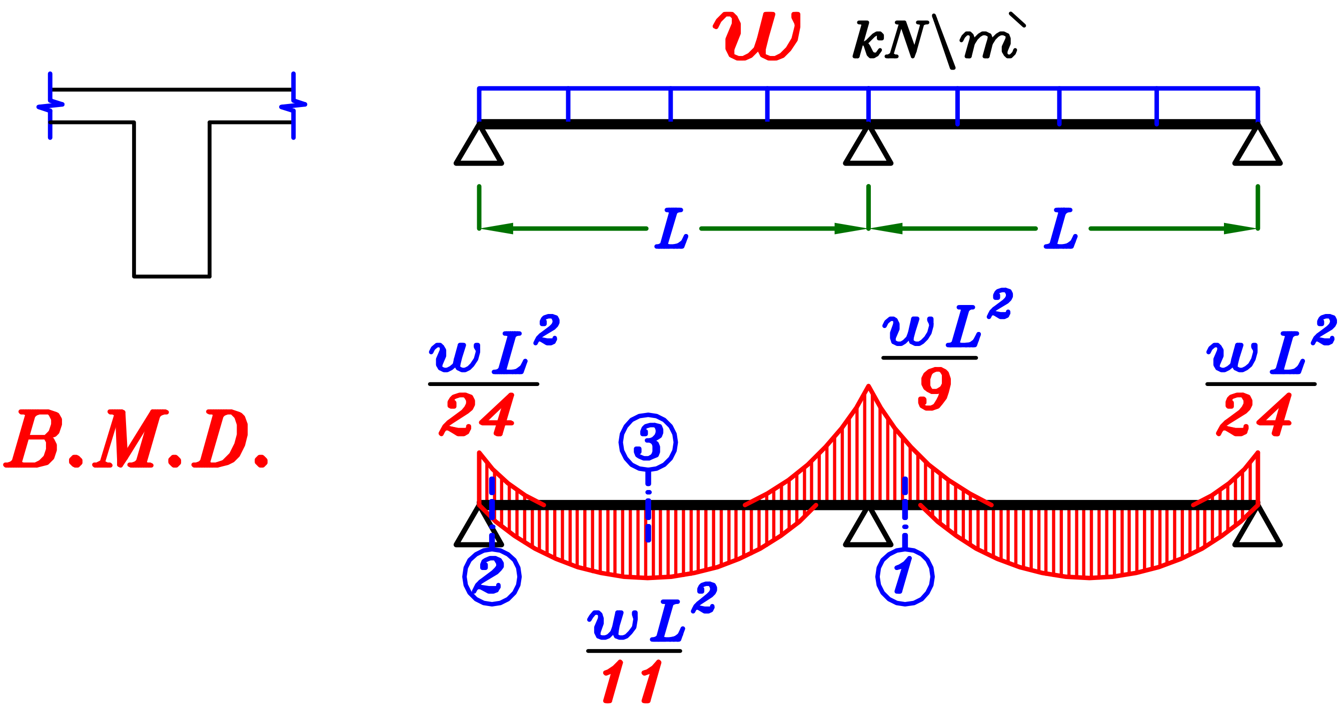


Inverted Beam. كمره مقلوبه

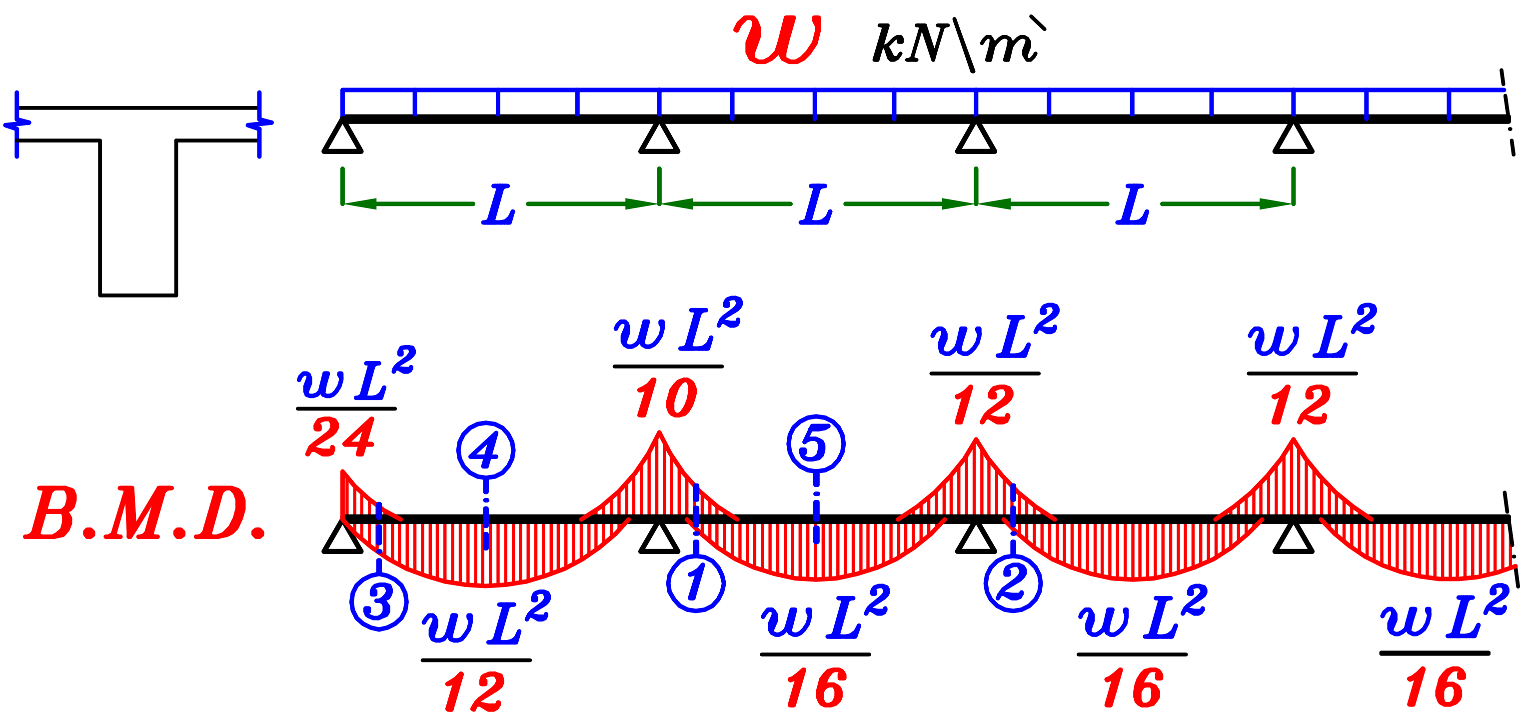


Continuous Beams.

① Continuous Beam with 2 spans.

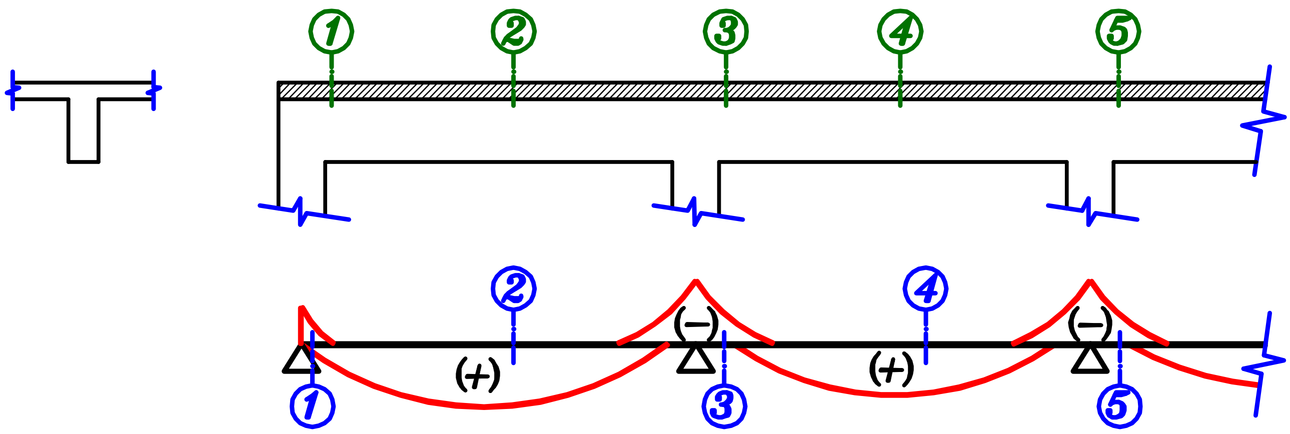


② Continuous Beam with more than 2 spans.



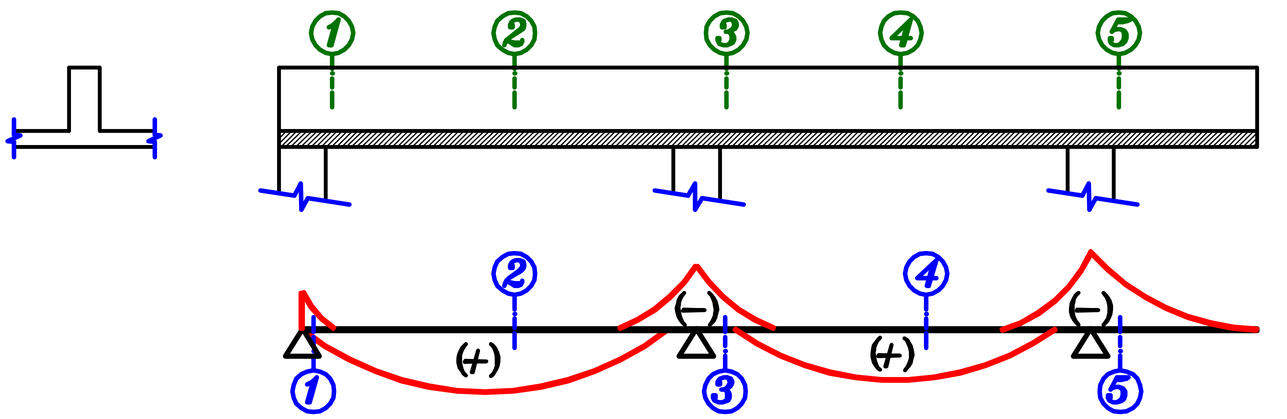
Example. Find the type of Sections.

Projected Beam. كمره ساقطه



Sec.	Sec. (1)	Sec. (2)	Sec. (3)	Sec. (4)	Sec. (5)
Type of Section	R-Sec.	T-Sec.	R-Sec.	T-Sec.	R-Sec.
K	—	0.8	—	0.7	—

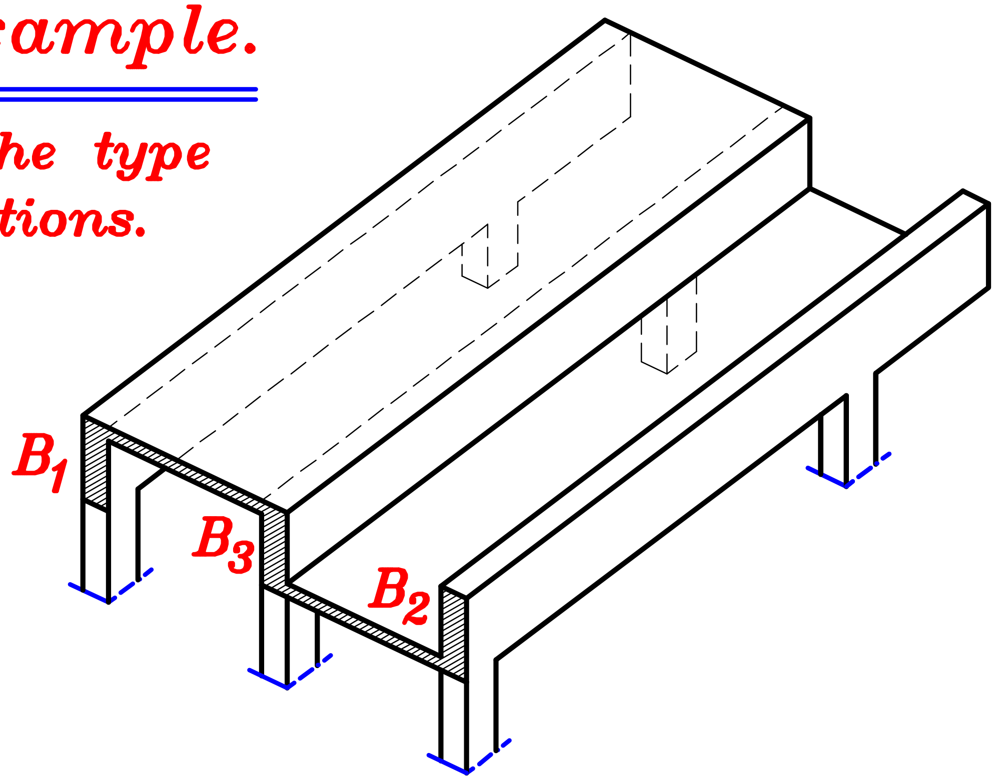
Inverted Beam. كمره مقلوبه



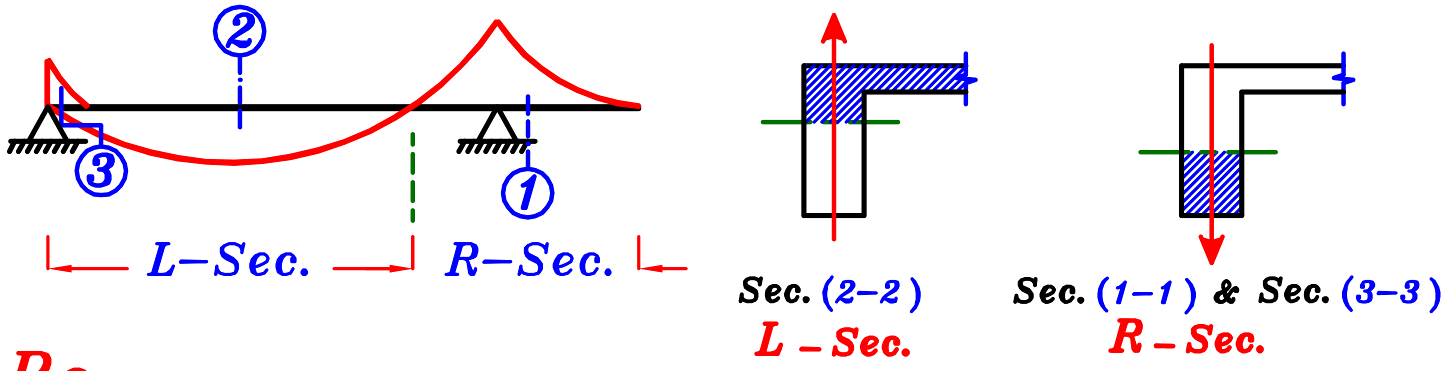
Sec.	Sec. (1)	Sec. (2)	Sec. (3)	Sec. (4)	Sec. (5)
Type of Section	T-Sec.	R-Sec.	T-Sec.	R-Sec.	T-Sec.
K	0.15	—	0.3	—	2.0

Example.

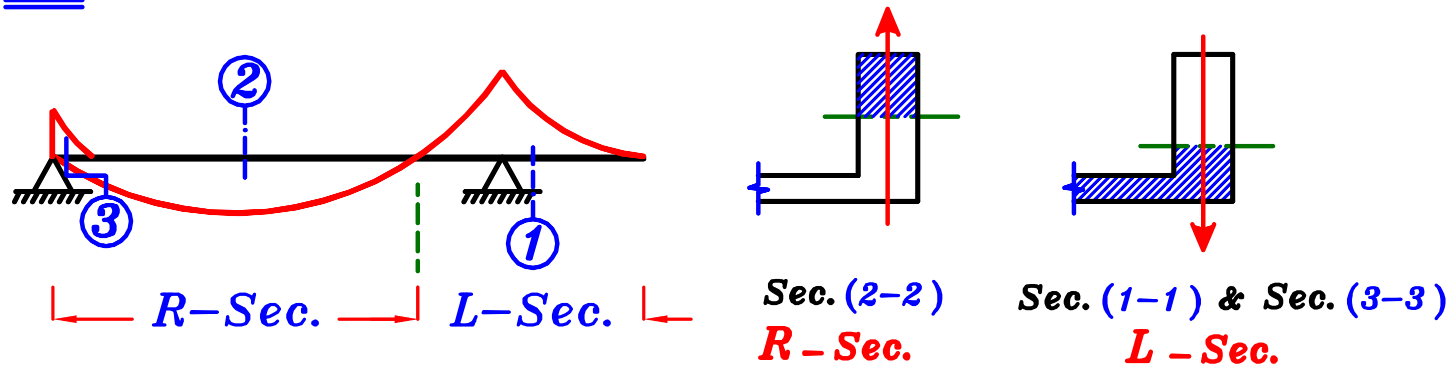
Find the type of Sections.



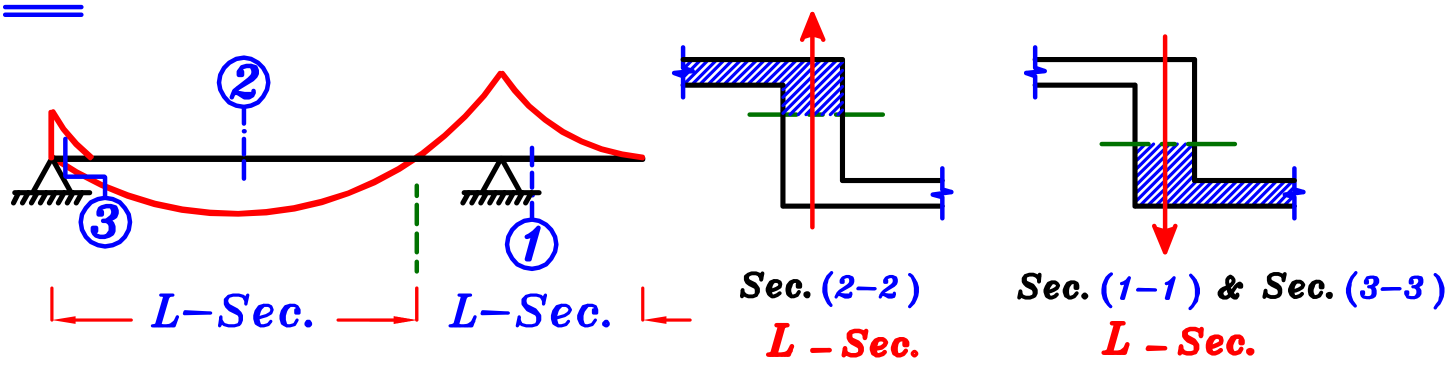
B_1



B_2

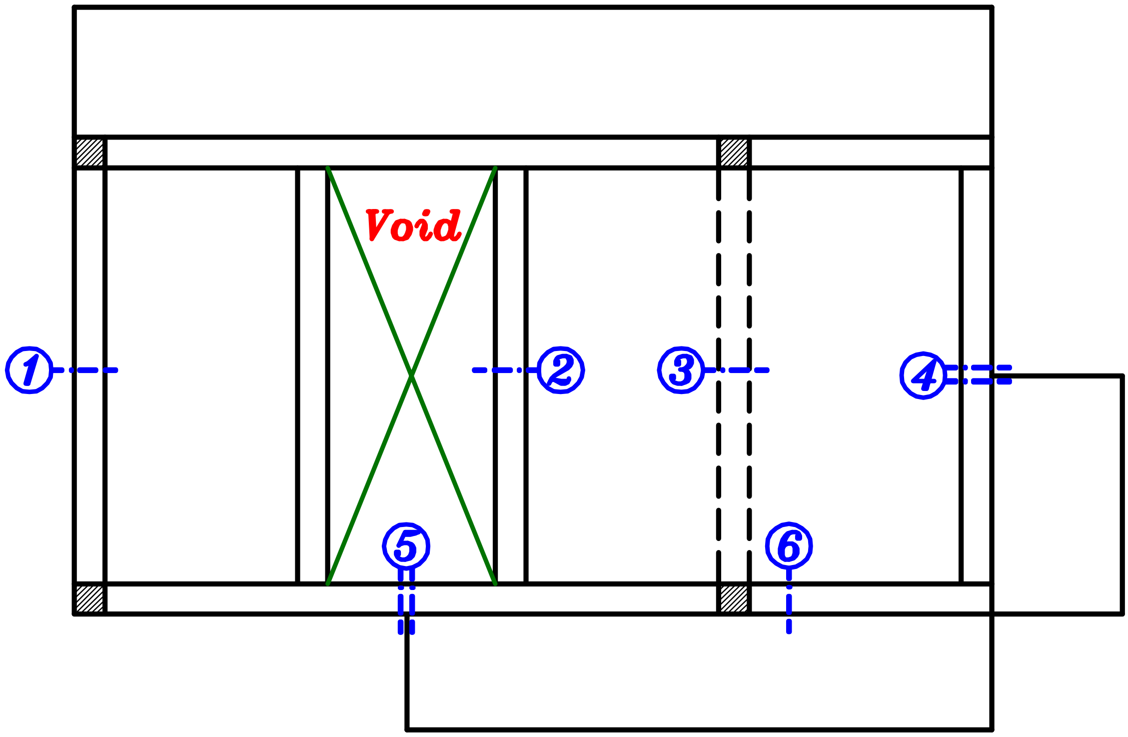


B_3

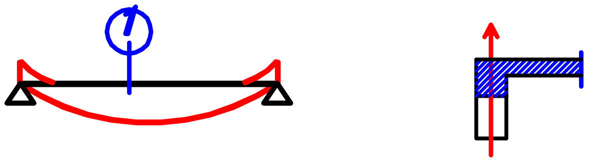


Example.

ملحوظه : إذا وُجِّد قطاع ممكن أن يكون نوعان من القطاعات
نصممة على القطاع الأضعف .

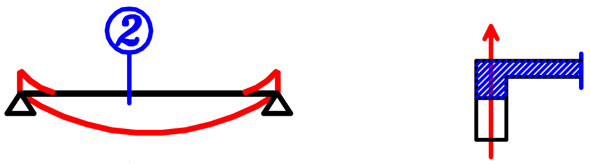


Sec. (1−1)



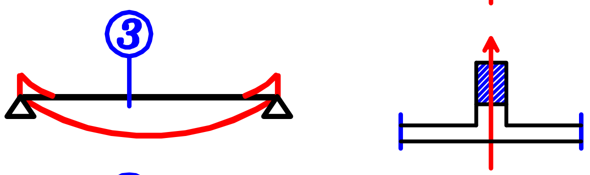
Designed as L−Sec.

Sec. (2−2)



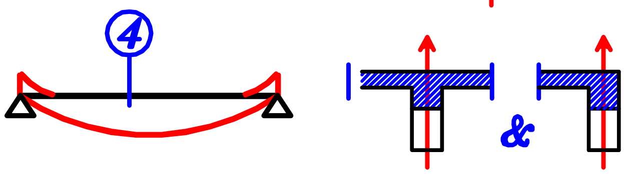
Designed as L−Sec.

Sec. (3−3)



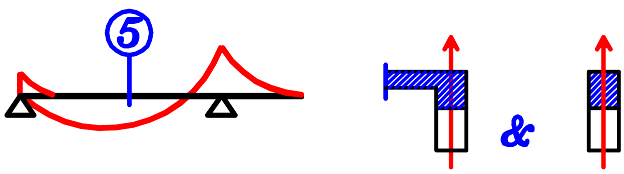
Designed as R−Sec.

Sec. (4−4)



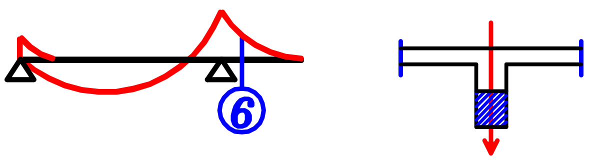
Designed as L−Sec.

Sec. (5−5)



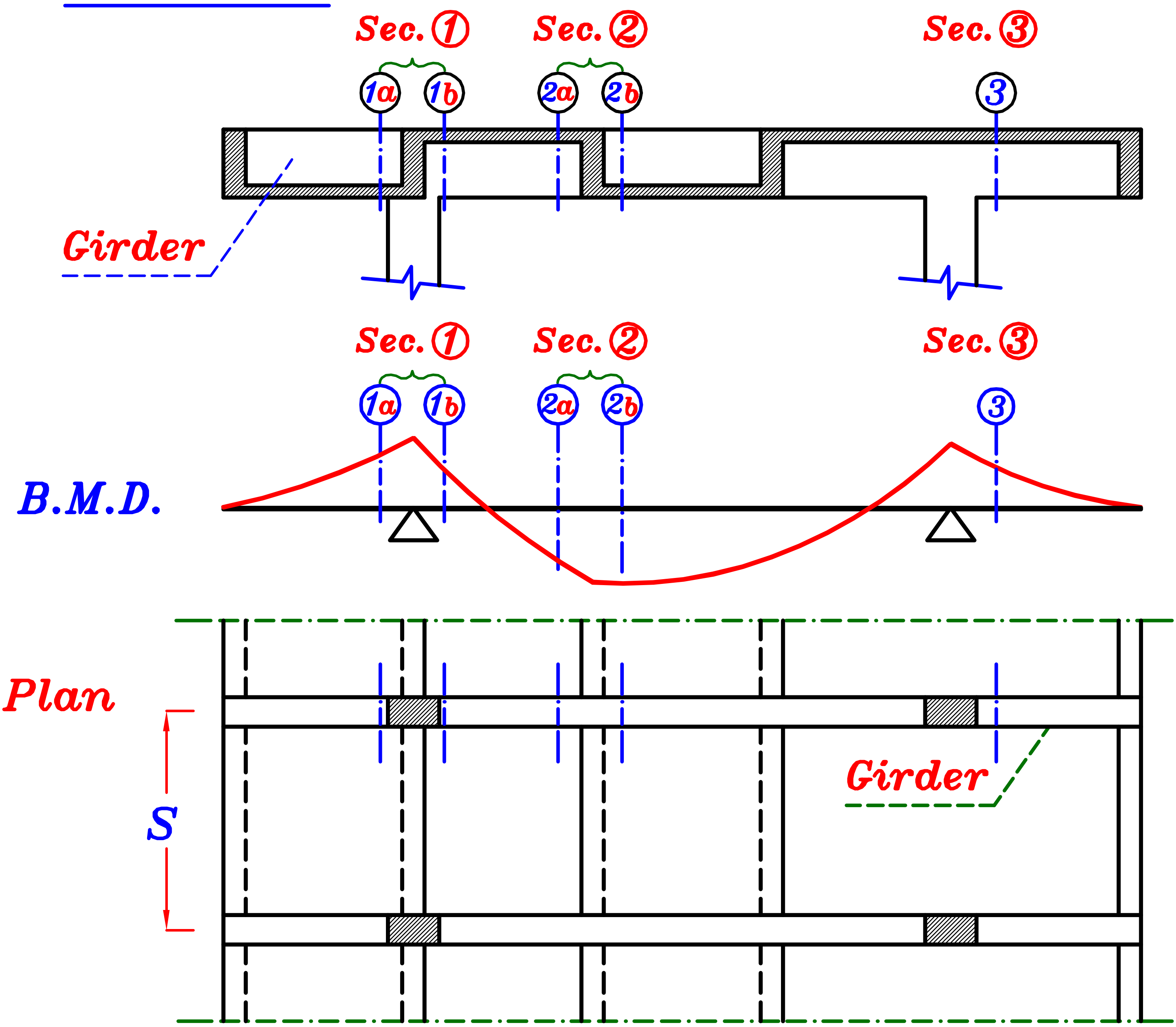
Designed as R−Sec.

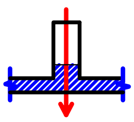
Sec. (6−6)

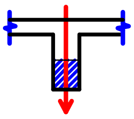


Designed as R−Sec.

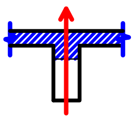
Example.

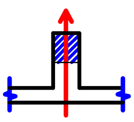


Sec. 1a  T-Sec.

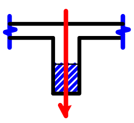
Sec. 1b  R-Sec.

Design Sec. 1 as R-Sec.

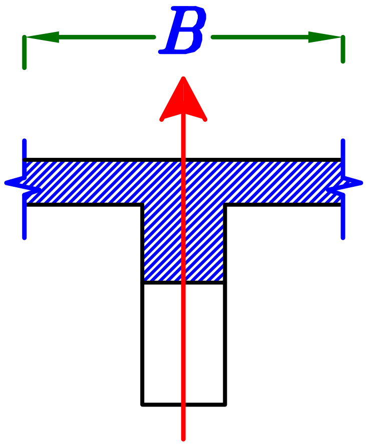
Sec. 2a  T-Sec.

Sec. 2b  R-Sec.

Design Sec. 2 as R-Sec.

Sec. 3  Design Sec. 3 as R-Sec.

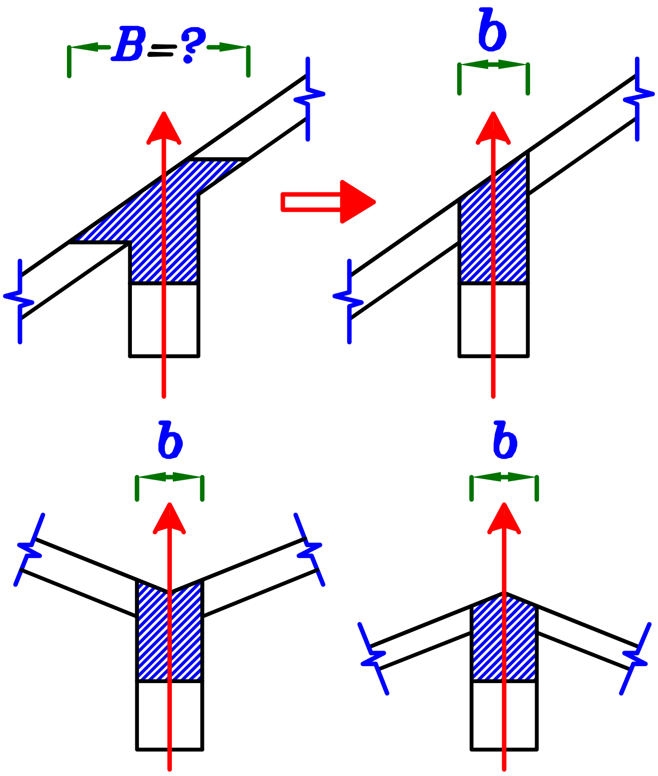
Design of Sections with Inclined Slabs.



اذا كانت البلاطه ظاهره فى ال cross section أفقيه

ممكن ان نحسب قيمه B من القانون التالى

$$B = \left\{ \begin{array}{l} \underset{slab}{C.L.} - \underset{slab}{C.L.} \\ 16\, t_s + b \\ K\,\dfrac{L}{5} + b \end{array} \right\} \text{الأقل}$$



اما اذا كانت البلاطه ظاهره فى

ال cross section مائله

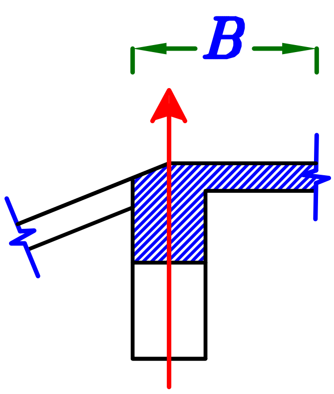
فلا توجد لدينا قوانين دقيقه

لحساب B

لذلك لزياده الامان نعتبر ان b فقط

هى من تقاوم فى القطاع

مثل ال R−Sec.



اما اذا كانت البلاطه ظاهره فى

ال cross section جهه مائله و جهه افقيه

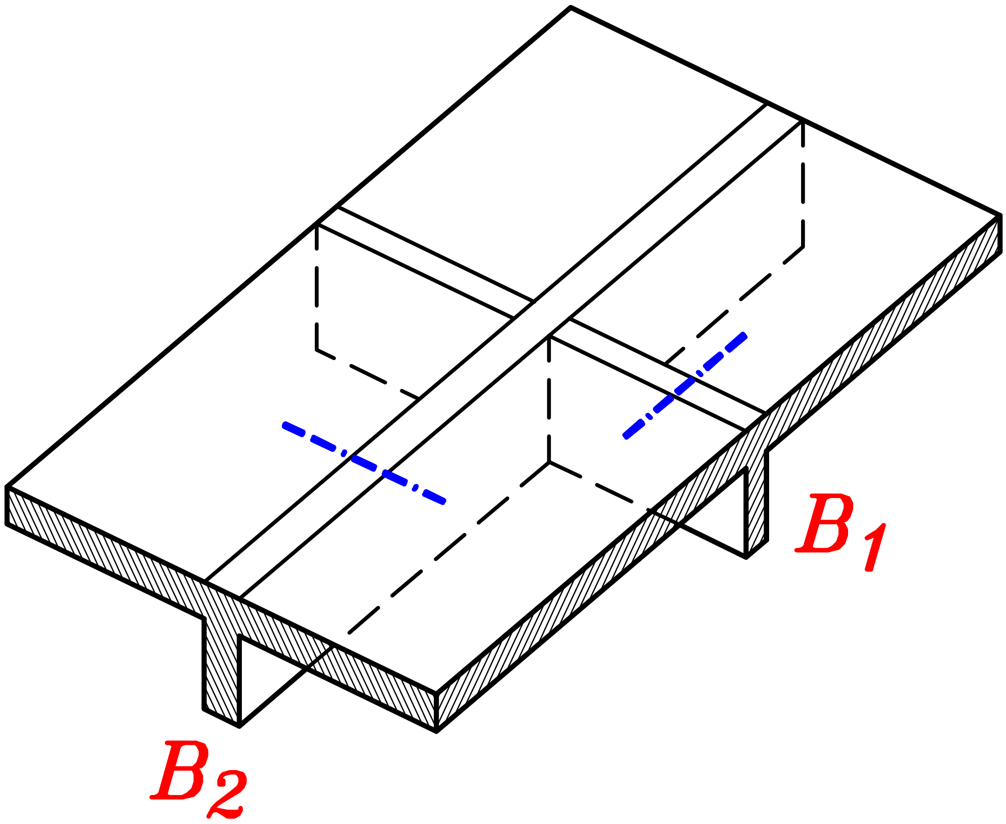
ممكن حساب قيمه B من الجهه الافقيه فقط

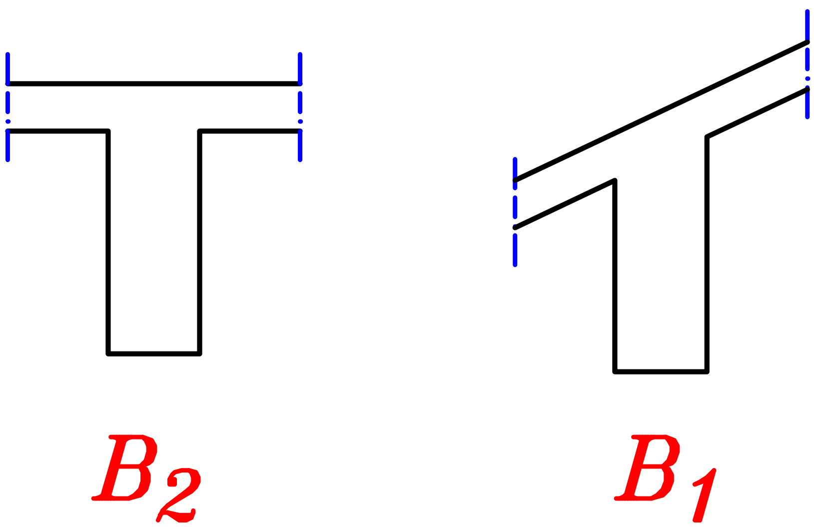
مثل L−Sec.

$$B = \left\{ \begin{array}{l} \underset{beam}{C.L.} - \underset{slab}{C.L.} \\ 6\, t_s + b \\ K\,\dfrac{L}{10} + b \end{array} \right\} \text{الأقل}$$

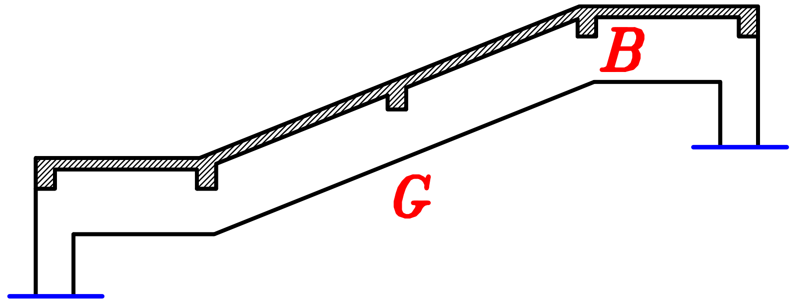
Note.

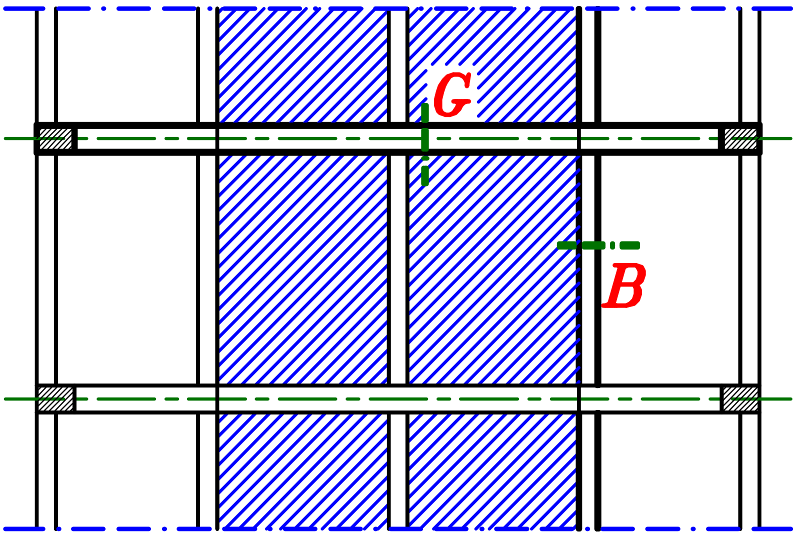
من الممكن ان تكون البلاطه فى الحقيقه مائله
لكن فى رسمه الـ cross section ممكن
ان تكون البلاطه شكلها افقى .



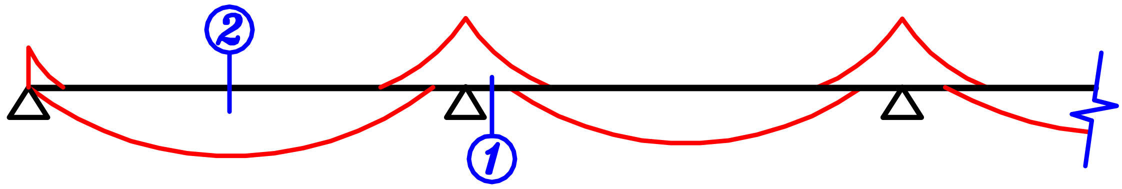


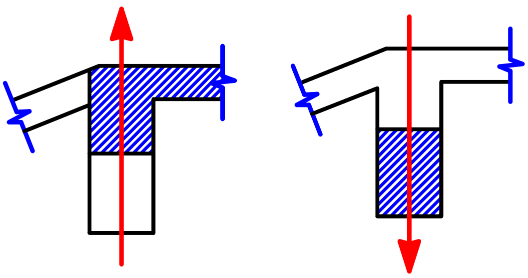
Example.





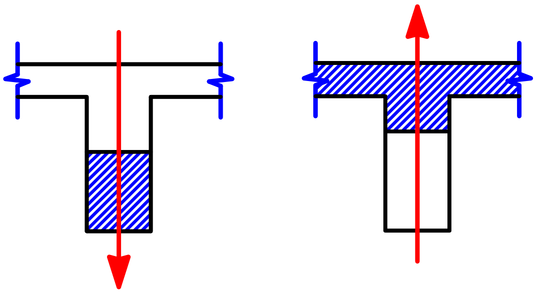
B



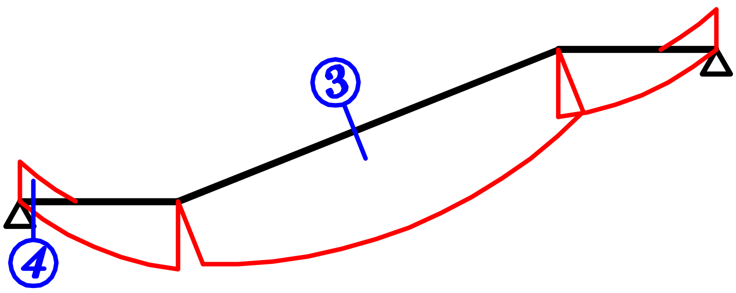


Sec. 2 Sec. 1

G



Sec. 4 Sec. 3



اذا كانت الكمره يؤثر عليها M_Y و M_X معاً و لا يؤثر عليها P

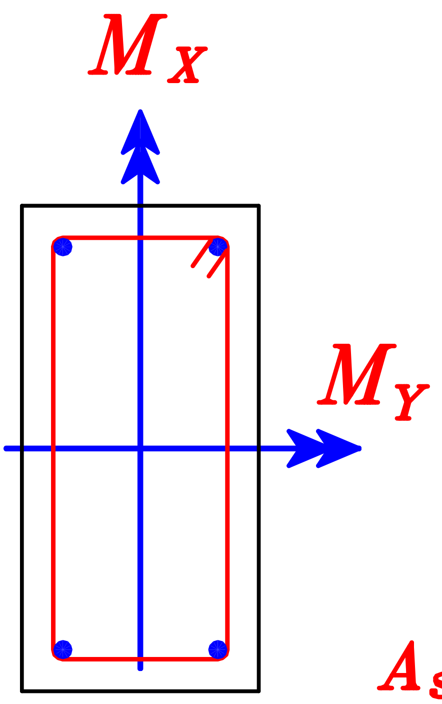
و يتم تصميم قطاع الكمره مرتين :

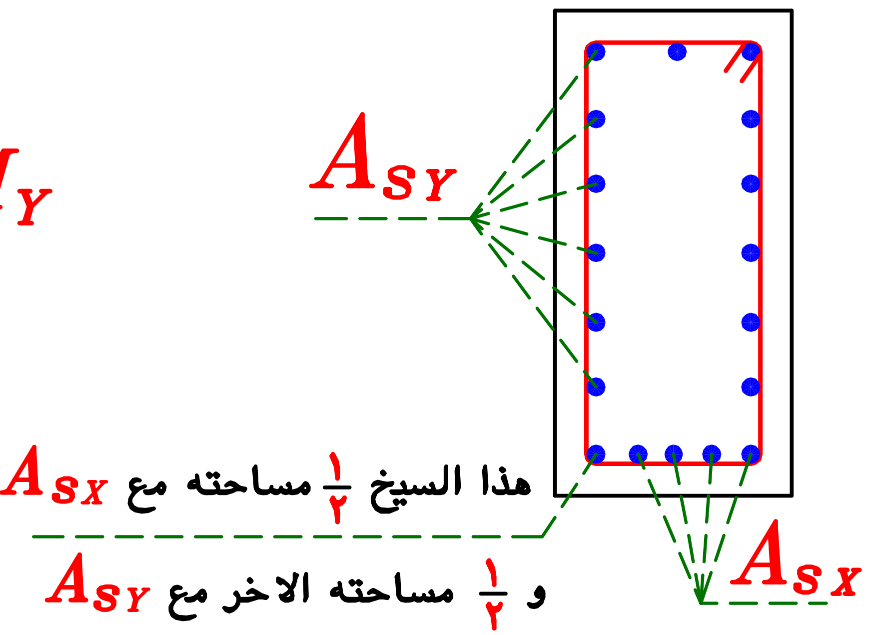
١- يتم تصميم قطاع الكمره على M_X فقط و تحديد قيمه $A_{s\,X}$

Check $A_{sX} > A_{s\,min} = \mu_{min.}\, b\, d \xrightarrow{IF\ not} Take\ A_{sX} = A_{s\,min}$

٢- يتم تصميم قطاع الكمره على M_Y فقط و تحديد قيمه $A_{s\,Y}$

Check $A_{sY} > A_{s\,min} = \mu_{min.}\, b\, d \xrightarrow{IF\ not} Take\ A_{sY} = A_{s\,min}$





Example on design using C_1 & J

Example.

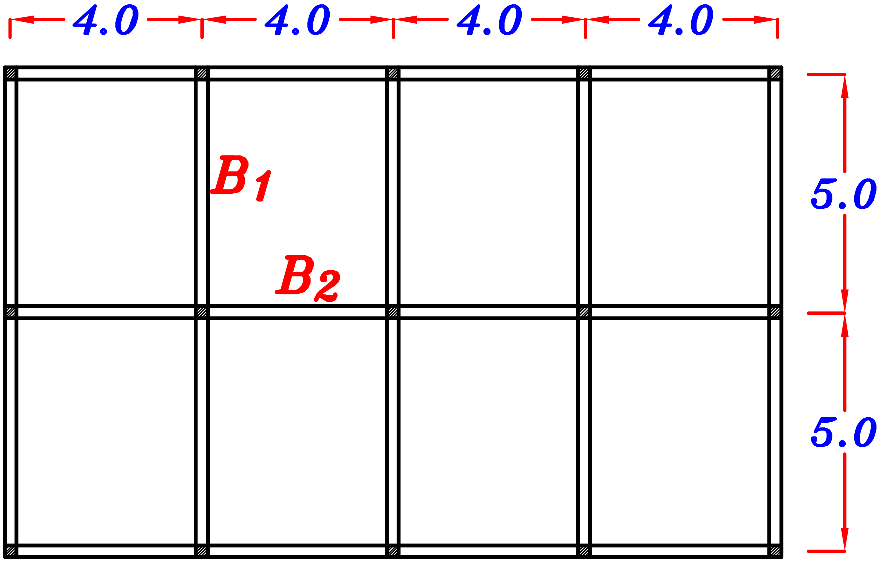
$F_{cu} = 25$ N\mm²

st. 360/520

$t_s = 140$ mm

F.C. = 2.0 kN\m²

L.L. = 2.0 kN\m²



Req.

1- Draw the absolute B.M.D. For beams B_1 & B_2

2- Design the critical sections For bending using charts.

3- Draw details of RFT. For Beams using Imperical Method.

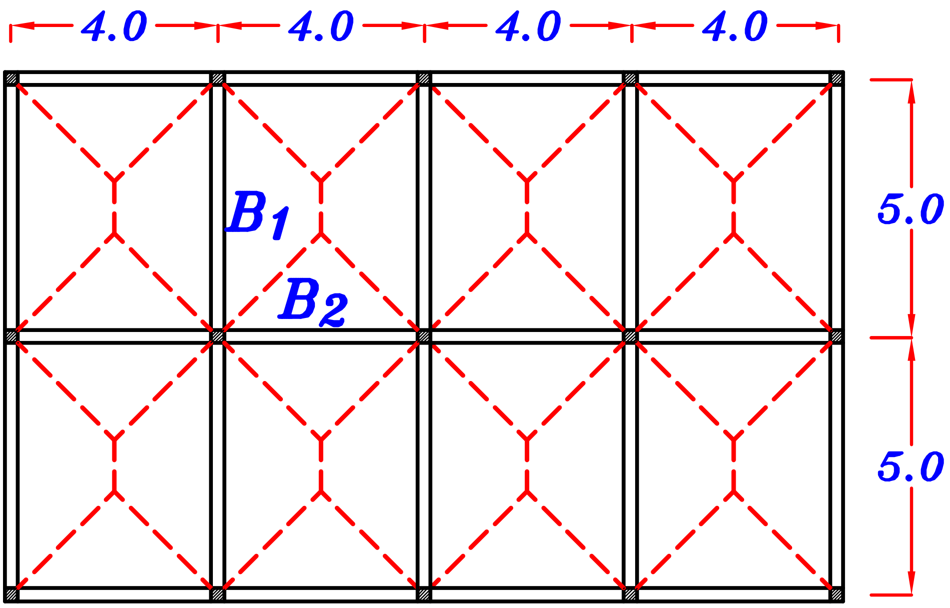
Solution.

∵ The Beams is continuos beams

∴ The cases of Loading is only T.L.

Take o.w. (beam) = 3.0 kN\m` (Working)

$w_s = t_s * \gamma_c + F.C. + L.L. = 0.14 * 25 + 2.0 + 2.0 = 7.50$ kN\m²



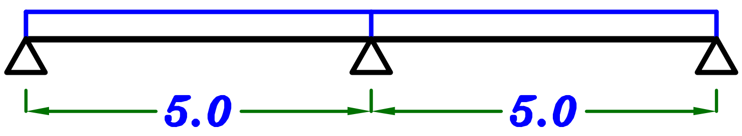
B_1

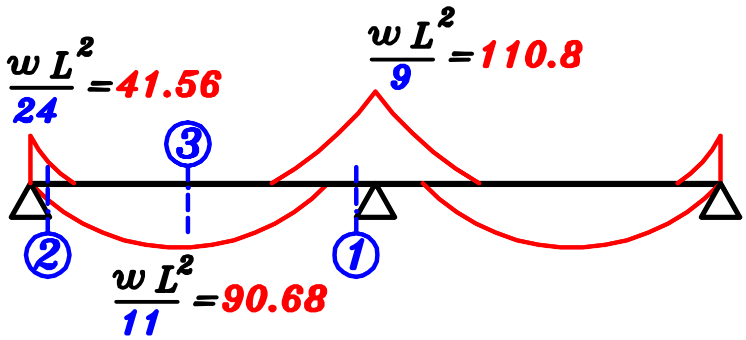
$$C_e = 1 - \frac{1}{3}\left(\frac{L_s}{L}\right)^2 = 1 - \frac{1}{3}\left(\frac{4.0}{5.0}\right)^2 = 0.7866$$

$$w_e = o.w. + 2\, C_e\, w_s\, \frac{L_s}{2} = 3.0 + 2\,(0.7866)\,(7.50)\,\left(\frac{4}{2}\right) = 26.60 \ \text{kN\textbackslash m}$$

$$(w_e)_{U.L.} = 1.50 * 26.60 = 39.90 \ \text{kN\textbackslash m}$$

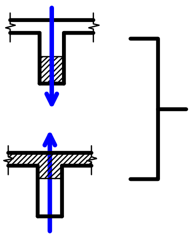
$w_e = 39.90$ kN\m





Sec. 1 $M_{U.L.} = 110.8$ kN.m R–Sec.

Sec. 3 $M_{U.L.} = 90.68$ kN.m T–Sec.



$\because$ $M_T < 2\, M_R$

$\therefore$ Design R–Sec. at First.

Sec. 1 $M_{U.L.} = 110.8$ kN.m R–Sec.

- Take C_1 between $(3.0 \longrightarrow 4.0)$ $C_1 = 3.50$
- From charts $C_1 = 3.50 \longrightarrow J = 0.78$
- Get $d = C_1 \sqrt{\dfrac{M_{U.L.}}{F_{cu}\, b}} = 3.50 \sqrt{\dfrac{110.8 * 10^6}{25 * 250}} = 466.0$ mm
- Take $\boxed{d = 500 \text{ mm}}$, $\boxed{t = 550 \text{ mm}}$
- Get $A_s = \dfrac{M_{U.L.}}{J\, F_y\, d} = \dfrac{110.8 * 10^6}{0.78 * 360 * 466.0} = 846.7 \text{ mm}^2$

- Check $A_{s_{min.}}$ $\qquad A_{s_{req.}} = 846.7\ mm^2$

$$\mu_{min.}\, b\, d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\, d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 250 * 500 = 390.6\ mm^2$$

$\therefore A_{s_{req.}} > \mu_{min.}\, b\, d$

$\therefore$ Take $A_s = A_{s_{req.}} = 846.7\ mm^2$ $\quad 5 \phi 16$

$$\therefore n = \frac{b - 25}{\phi + 25} = \frac{250 - 25}{16 + 25} = 5.48 = 5.0$$

Sec. ② $\qquad M_{U.L.} = 41.56\ kN.m \qquad$ R–Sec.

Take $d = 0.50\ m$ (The same d of Sec. ①)

$$\because d = C_1 \sqrt{\frac{M_{U.L.}}{F_{cu}\, b}} \quad \therefore 500 = C_1 \sqrt{\frac{41.56 * 10^6}{25 * 250}} \longrightarrow C_1 = 6.13$$

- From Charts. $C_1 = 6.13 > 4.85 \longrightarrow J = 0.826$

$$\therefore A_s = \frac{M_{U.L.}}{J\, F_y\, d} = \frac{41.56 * 10^6}{0.826 * 360 * 500} = 279.5\ mm^2$$

Check $A_{s_{min.}}$ $\qquad A_{s_{req.}} = 279.5\ mm^2$

$$\mu_{min.}\, b\, d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\, d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 250 * 500 = 390.6\ mm^2$$

$\therefore \mu_{min.}\, b\, d > A_{s_{req.}} \xrightarrow{\text{Use}} A_{s_{min.}}$

$$A_{s_{min.}} = 0.225 * \frac{\sqrt{F_{cu}}}{F_y}\, b\, d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 250 * 500 = 390.6$$

$$1.3\, A_{s_{req.}} = 1.3 * 279.5 = 363.3$$

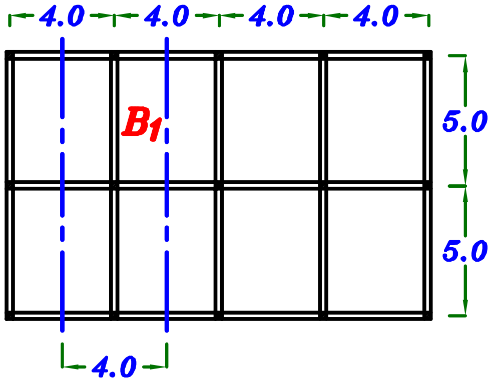
الأقل $= 363.3$

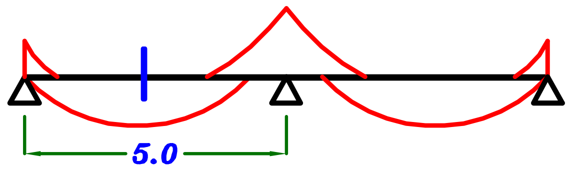
$$\text{st. } 360/520 \quad \frac{0.15}{100}\, b\, d = \frac{0.15}{100} * 250 * 500 = 187.5$$

الأكبر $= 363.3\ mm^2$ $\quad 2 \phi 16$

Sec. ③ $M_{U.L.} = 90.68$ kN.m T−Sec.

Take $d = 0.50$ m (The same d of Sec. ①)





$$B = \begin{cases} C.L. - C.L. = 4.0 \text{ m} = 4000 \text{ mm} \\ 16\, t_s + b = 16 * 140 + 250 = 2490 \text{ mm} \\ K \frac{L}{5} + b = 0.8 * \frac{5000}{5} + 250 = 1050 \text{ mm} \end{cases}$$

$$\boxed{B = 1050 \text{ mm}}$$

$$\because d = C_1 \sqrt{\frac{M_{U.L.}}{F_{cu}\, B}} \quad \therefore 500 = C_1 \sqrt{\frac{90.68 * 10^6}{25 * 1050}} \longrightarrow C_1 = 8.50$$

- From Charts. $C_1 = 8.50 > 4.85 \longrightarrow J = 0.826$

$$\therefore A_s = \frac{M_{U.L.}}{J\, F_y\, d} = \frac{90.68 * 10^6}{0.826 * 360 * 500} = 609.9 \text{ mm}^2$$

- Check $A_{s_{min.}}$ $\quad A_{s_{req.}} = 609.9 \text{ mm}^2$

$$\mu_{min.}\, b\, d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\, d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 250 * 500 = 390.6 \text{ mm}^2$$

$$\therefore A_{s_{req.}} > \mu_{min.}\, b\, d$$

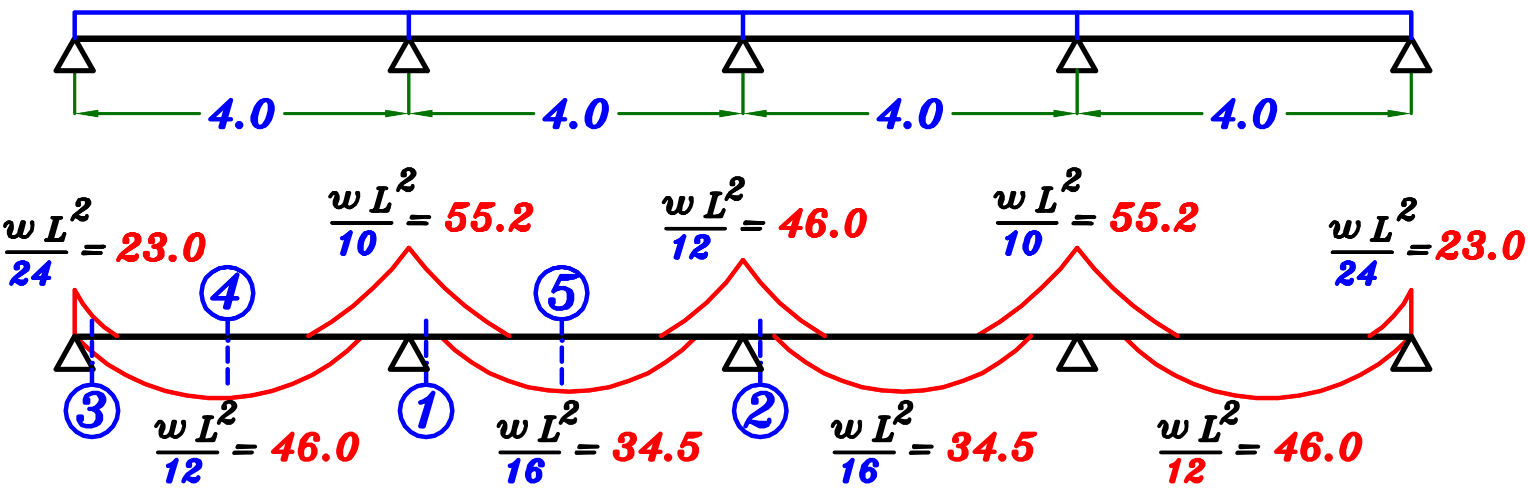
$$\therefore \text{Take } A_s = A_{s_{req.}} = 609.9 \text{ mm}^2 \quad 4 \phi 16$$

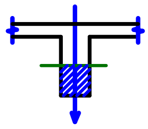
B2 $\quad C_e = \frac{2}{3}$ For Triangles

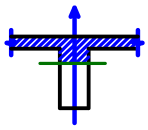
$$w_e = o.w. + 2\, C_e\, w_s \frac{L_s}{2} = 3.0 + 2\left(\frac{2}{3}\right)(7.50)\left(\frac{4}{2}\right) = 23.0 \ kN\backslash m'$$

$$(w_e)_{U.L.} = 1.50 * 23.0 = 34.5 \ kN\backslash m'$$

$$w_e = 34.5 \ kN\backslash m'$$



Sec. ① $M_{U.L.} = 55.2$ kN.m R-Sec. 

Sec. ④ $M_{U.L.} = 46.0$ kN.m T-Sec. 

$\because M_T < 2\, M_R \quad \therefore$ Design R-Sec. at First.

Sec. ① $\quad M_{U.L.} = 55.2$ kN.m $\quad$ R-Sec.

- Take C_1 between $(3.0 \longrightarrow 4.0)$ $\quad C_1 = 3.50$
- From charts $\quad C_1 = 3.50 \longrightarrow J = 0.78$
- Get $d = C_1 \sqrt{\frac{M_{U.L.}}{F_{cu}\, b}} = 3.50 \sqrt{\frac{55.2 * 10^6}{25 * 250}} = 328.9$ mm
- Take $\boxed{d = 350 \ mm}$, $\boxed{t = 400 \ mm}$

$$A_s = \frac{M_{U.L.}}{J\, F_y\, d} = \frac{55.2 * 10^6}{0.78 * 360 * 328.9} = 597.7 \ mm^2$$

- **Check $A_{s_{min.}}$** $\qquad A_{s_{req.}} = 597.7\ mm^2$

$$\mu_{min.}\, b\, d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\, d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 250 * 350 = 273.4\ mm^2$$

$$\therefore A_{s_{req.}} > \mu_{min.}\, b\, d$$

$$\therefore \text{Take } A_s = A_{s_{req.}} = 597.7\ mm^2 \qquad 6\ \phi\ 12$$

$$\therefore n = \frac{b - 25}{\phi + 25} = \frac{250 - 25}{12 + 25} = 6.08 = 6.0$$

Sec. ②

$M_{U.L.} = 46.0\ kN.m \qquad$ **R–Sec.**

Take $d = 0.35\ m$ (The same d of Sec. ①)

$$\because d = C_1 \sqrt{\frac{M_{U.L.}}{F_{cu}\, b}} \quad \therefore 350 = C_1 \sqrt{\frac{46.0 * 10^6}{25 * 250}} \longrightarrow C_1 = 4.08$$

- From Charts. $C_1 = 4.04 \longrightarrow J = 0.805$

$$\therefore A_s = \frac{M_{U.L.}}{J\, F_y\, d} = \frac{46.0 * 10^6}{0.805 * 360 * 350} = 453.51\ mm^2$$

- **Check $A_{s_{min.}}$** $\qquad A_{s_{req.}} = 453.51\ mm^2$

$$\mu_{min.}\, b\, d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\, d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 250 * 350 = 273.4\ mm^2$$

$$\therefore A_{s_{req.}} > \mu_{min.}\, b\, d$$

$$\therefore \text{Take } A_s = A_{s_{req.}} = 453.51\ mm^2 \qquad 4\ \phi\ 12$$

Sec. ③ $M_{U.L.} = 23.0$ kN.m R–Sec.

Take $d = 0.35$ m (The same d of Sec. ①)

$$\because d = C_1 \sqrt{\frac{M_{U.L.}}{F_{cu}\, b}} \quad \therefore 350 = C_1 \sqrt{\frac{23.0 * 10^5}{25 * 250}} \longrightarrow C_1 = 5.77$$

– From Charts. $C_1 = 5.77 > 4.85 \longrightarrow J = 0.826$

$$\therefore A_S = \frac{M_{U.L.}}{J\, F_y\, d} = \frac{23.0 * 10^6}{0.826 * 360 * 350} = 221.0\ mm^2$$

Check $A_{s_{min.}}$ $A_{s_{req.}} = 221.0\ mm^2$

$$\mu_{min.}\, b\, d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\, d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 250 * 350 = 273.4\ mm^2$$

$$\therefore \mu_{min.}\, b\, d > A_{s_{req.}} \xrightarrow{\text{Use}} A_{s_{min.}}$$

$$A_{s_{min.}} = 0.225 * \frac{\sqrt{F_{cu}}}{F_y}\, b\, d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 250 * 350 = 273.4$$

$$1.3\, A_{s_{req.}} = 1.3 * 221.0 = 287.3$$

الأقل $= 273.4$

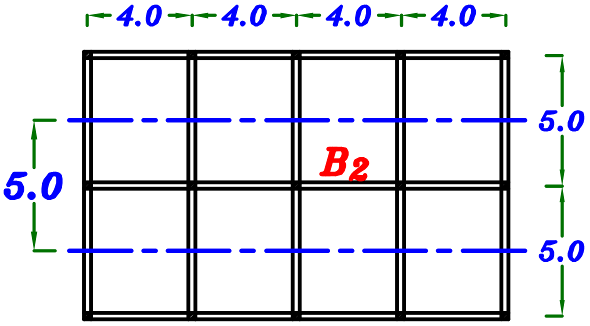
st. 360/520 $\frac{0.15}{100}\, b\, d = \frac{0.15}{100} * 250 * 350 = 131.2$

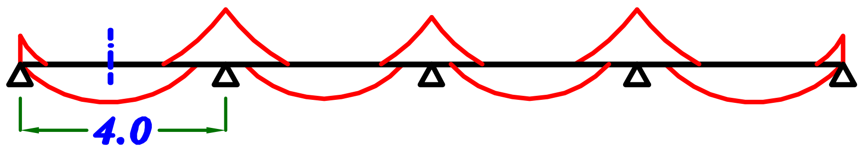
الأكبر $= 273.4\ mm^2$

$3\ \phi\ 12$

Sec. 4 $M_{U.L.} = 46.0$ kN.m T–Sec.

Take $d = 0.35$ m (The same d of Sec. 1)





$$B = \begin{cases} C.L. - C.L. = 5.0\ m = 5000\ mm \\ 16\ t_s + b = 16 * 140 + 250 = 2490\ mm \\ K \dfrac{L}{5} + b = 0.8 * \dfrac{4000}{5} + 250 = 890\ mm \end{cases} \qquad \boxed{B = 890\ mm}$$

$$\because\ d = C_1 \sqrt{\frac{M_{U.L.}}{F_{cu}\ B}} \quad \therefore\ 350 = C_1 \sqrt{\frac{46.0 * 10^6}{25 * 890}} \longrightarrow C_1 = 7.69$$

– From Charts $C_1 = 7.69 > 4.85 \longrightarrow J = 0.826$

$$\therefore\ A_s = \frac{M_{U.L.}}{J\ F_y\ d} = \frac{46.0 * 10^6}{0.826 * 360 * 350} = 442.0\ mm^2$$

– Check $A_{s_{min.}}$ $\qquad A_{s_{req.}} = 442.0\ mm^2$

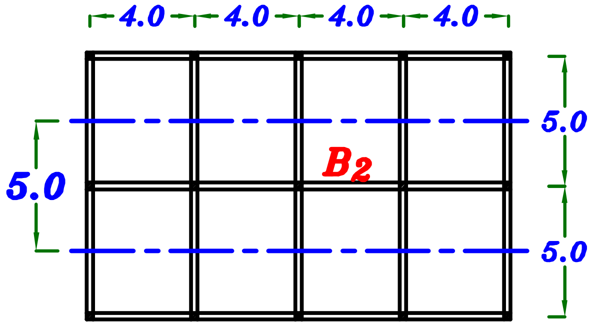
$$\mu_{min.}\ b\ d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\ d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 250 * 350 = 273.4\ mm^2$$

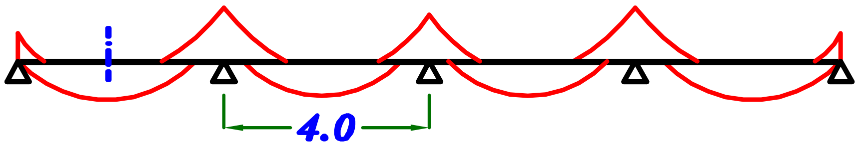
$$\therefore\ A_{s_{req.}} > \mu_{min.}\ b\ d$$

$\therefore$ Take $A_s = A_{s_{req.}} = 442.0\ mm^2$ $\qquad$ 4 ϕ 12

Sec. ⑤ $\quad M_{U.L.} = 34.5$ kN.m $\quad$ T−Sec.

Take $d = 0.35$ m (The same d of Sec. ①)





$$B = \begin{cases} C.L. - C.L. = 5.0\ m = 5000\ mm \\ 16\, t_s + b = 16 * 140 + 250 = 2490\ mm \\ K \dfrac{L}{5} + b = 0.7 * \dfrac{4000}{5} + 250 = 810\ mm \end{cases} \qquad \boxed{B = 810\ mm}$$

$$\because\ d = C_1 \sqrt{\frac{M_{U.L.}}{F_{cu}\, B}} \qquad \therefore\ 350 = C_1 \sqrt{\frac{34.5 * 10^6}{25 * 810}} \longrightarrow C_1 = 8.48$$

− From Charts $\quad C_1 = 8.48 > 4.85 \longrightarrow J = 0.826$

$$\therefore\ A_s = \frac{M_{U.L.}}{J\, F_y\, d} = \frac{34.5 * 10^6}{0.826 * 360 * 350} = 331.5\ mm^2$$

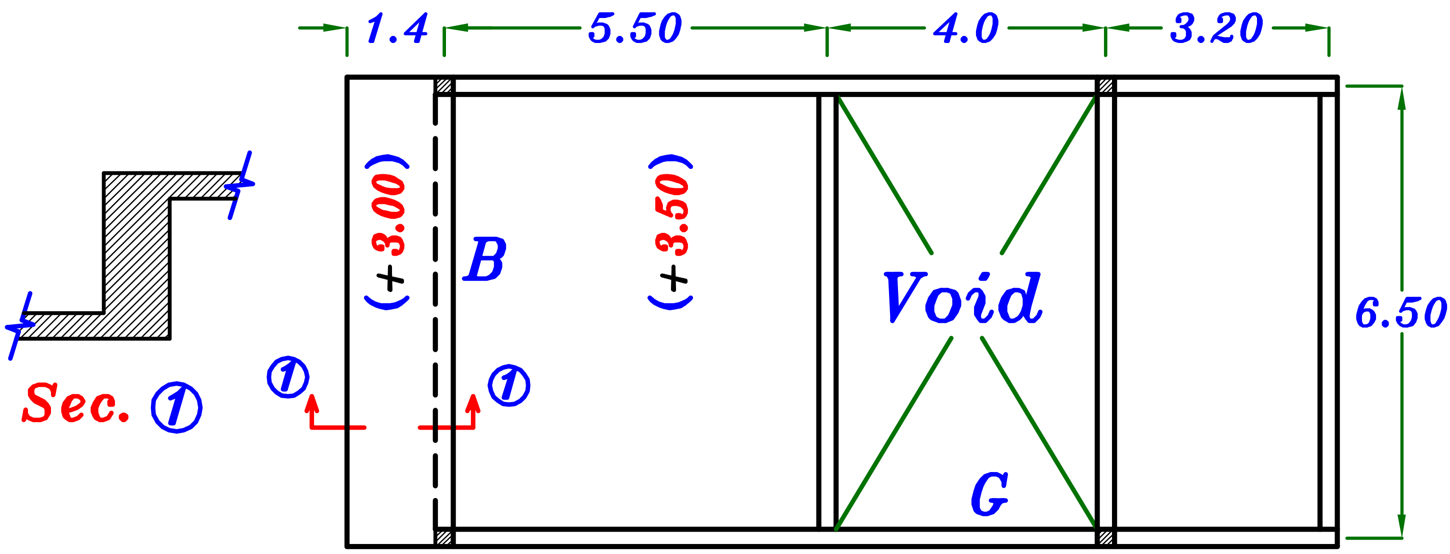
− Check $A_{s_{min.}}$ $\qquad A_{s_{req.}} = 331.5\ mm^2$

$$\mu_{min.}\, b\, d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\, d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 250 * 350 = 273.4\ mm^2$$

$$\therefore\ A_{s_{req.}} > \mu_{min.}\, b\, d$$

$$\therefore\ \text{Take}\ A_s = A_{s_{req.}} = 331.5\ mm^2 \qquad 3 \phi 12$$

Example.



$F_{cu} = 25$ N\mm^2 , st. 400/600 , $t_s = 150$ mm

F.C. = 2.0 kN\m^2 , L.L. = 3.0 kN\m^2

Req.

1- Draw the absolute B.M.D. For beam B & Girder G

2- Design the critical sections For bending using charts.

3- Draw details of RFT. For Beams using Imperical Method.

Solution.

Take o.w. (beam) = 3.0 kN\m' (Working)

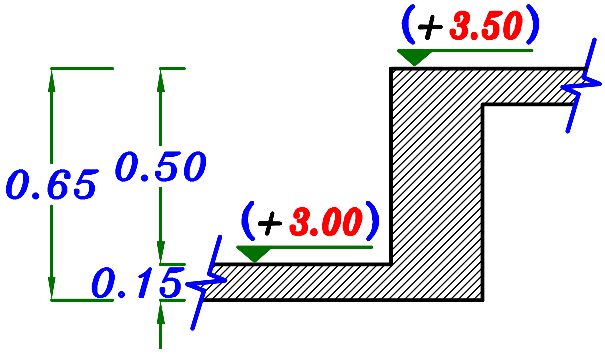
Take o.w. (girder) = 5.0 kN\m' (Working)

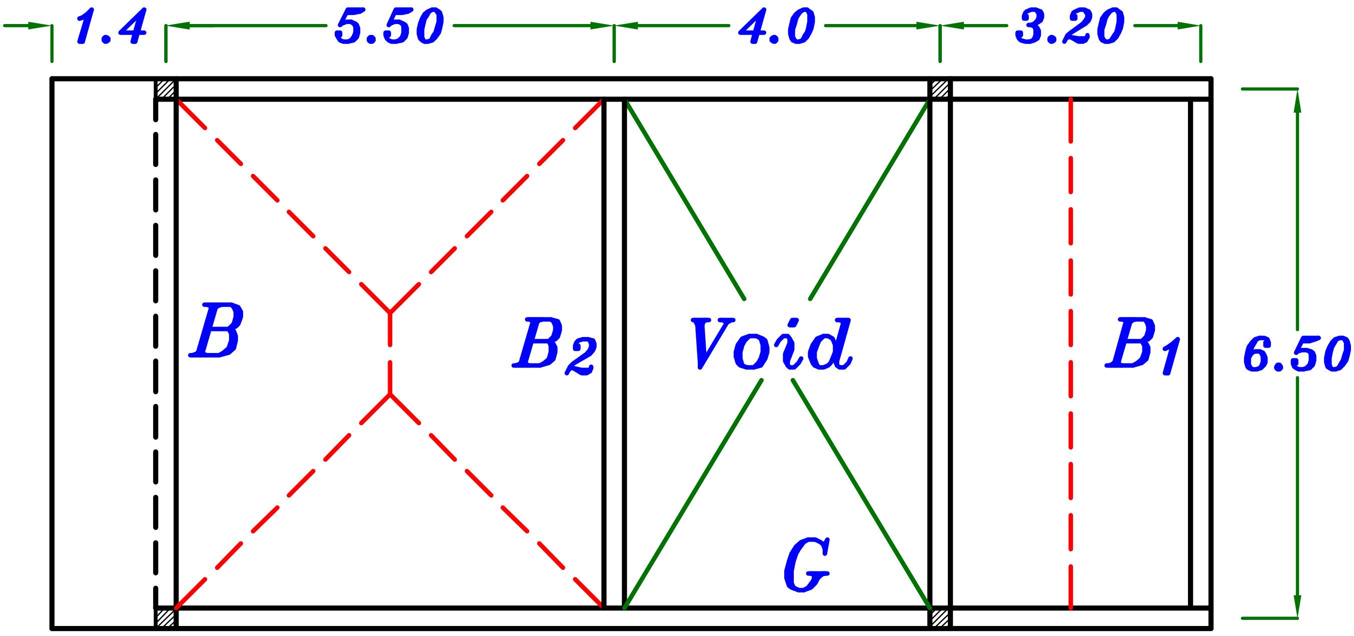
$g_s = t_s * \gamma_c + F.C. = 0.15 * 25 + 2.0 = 5.75$ kN\m^2

$p_s = L.L. = 3.0$ kN\m^2

$\boxed{g_s = 5.75 \text{ kN\\m}^2}$, $\boxed{p_s = 3.0 \text{ kN\\m}^2}$

Depth of Beam B is given = 0.65 m





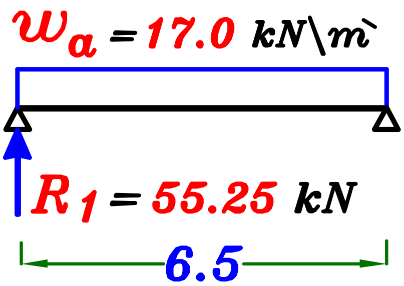
B_1 Load For Shear = Load For Moment

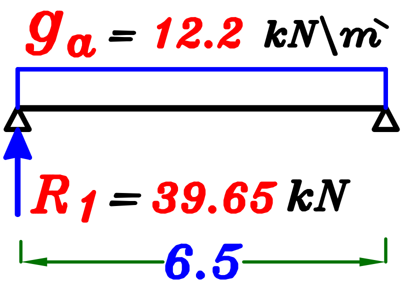
$$g_a = g_e = O.W. + g_s \frac{L_s}{2} = 3.0 + (5.75)\left(\frac{3.2}{2}\right) = 12.2 \ kN\backslash m'$$

$$p_a = p_e = p_s \frac{L_s}{2} = (3.0)\left(\frac{3.2}{2}\right) = 4.80 \ kN\backslash m'$$

$$w_a = w_e = g + p = 12.2 + 4.80 = 17.0 \ kN\backslash m'$$

$R_1 = 39.65$ kN --- D.L.
 55.25 kN --- T.L.





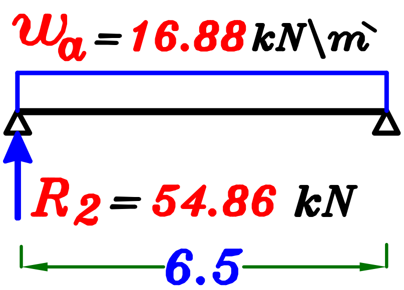
B_2 For Trapezoid $C_a = 1 - \frac{1}{2}\left(\frac{L_s}{L}\right) = 1 - \frac{1}{2}\left(\frac{5.5}{6.5}\right) = 0.577$

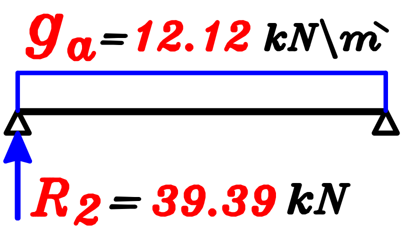
$$g_a = O.W. + C_a \, g_s \frac{L_s}{2} = 3.0 + (0.577)(5.75)\left(\frac{5.5}{2}\right) = 12.12 \ kN\backslash m'$$

$$p_a = C_a \, p_s \frac{L_s}{2} = (0.577)(3.0)\left(\frac{5.5}{2}\right) = 4.76 \ kN\backslash m'$$

$$w_a = g + p = 12.12 + 4.76 = 16.88 \ kN\backslash m'$$

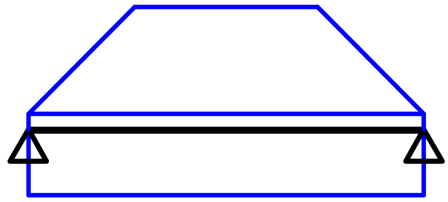
$R_2 = 39.39$ kN --- D.L.
 54.86 kN --- T.L.





B

For Trapezoid



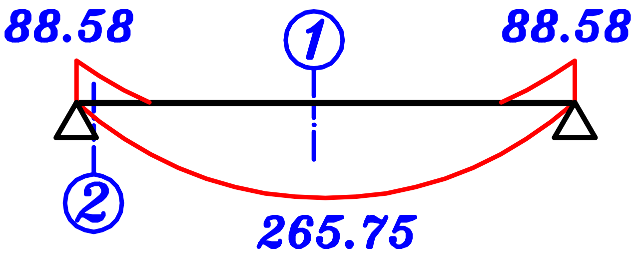
$$C_e = 1-\frac{1}{3}\left(\frac{L_s}{L}\right)^2 = 1-\frac{1}{3}\left(\frac{5.5}{6.5}\right)^2 = 0.761$$

$$g_e = O.W. + g_s\, L_c + C_e\, g_s \frac{L_s}{2} = 3.0 + (5.75)(1.4) + (0.761)(5.75)\left(\frac{5.5}{2}\right) = 23.08 \; kN\backslash m'$$

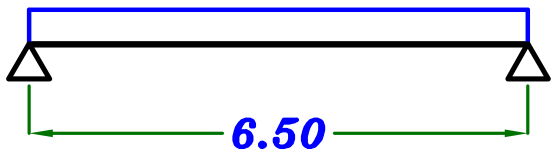
$$p_e = p_s\, L_c + C_e\, p_s \frac{L_s}{2} = (3.0)(1.4) + (0.761)(3.0)\left(\frac{5.5}{2}\right) = 10.47 \; kN\backslash m'$$

$$w_e = g_e + p_e = 23.08 + 10.47 = 33.55 \; kN\backslash m'$$

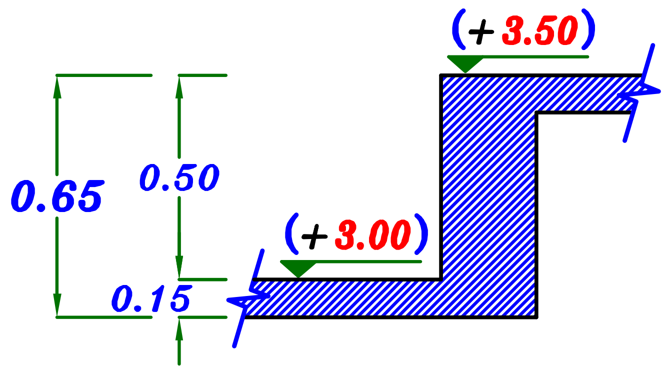
$$w_{U.L.} = 33.55 * 1.50 = 50.32 \; kN\backslash m'$$

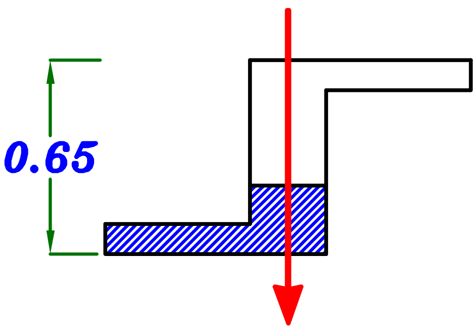


$w_e = 50.32 \; kN\backslash m'$

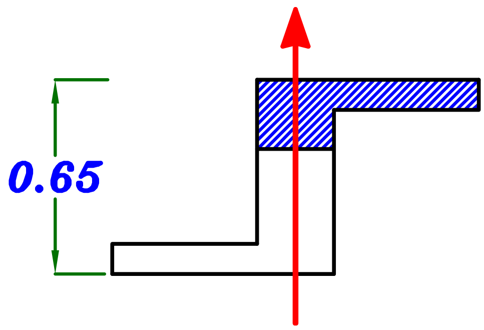


Depth Beam **B** is given $= 0.65\ m$





Sec. ②
L-sec.



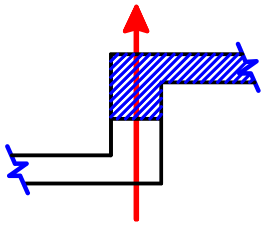
Sec. ①
L-sec.

ملحوظه

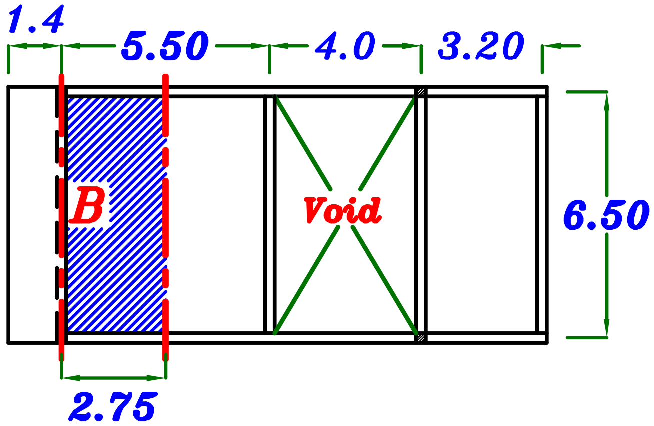
فى حاله أن عمق الكمره معطى ممكن تصميم أى قطاع قبل الاخر

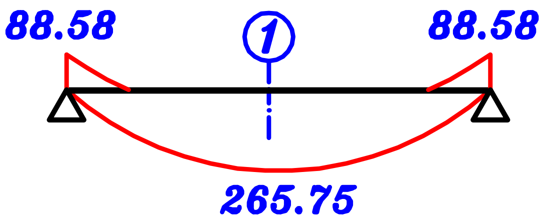
Sec. ①

$M_{U.L.} = 265.75$ kN.m L-Sec.



Take $d = 0.60$ m (as given in Data.)





$$B = \begin{cases} C.L.-C.L. = \dfrac{5500}{2} = 2750\ mm \\ 6\ t_s + b = 6 * 150 + 250 = 1150\ mm \\ K \dfrac{L}{10} + b = 1.0 * \dfrac{6500}{10} + 250 = 900\ mm \end{cases} \qquad \boxed{B = 900\ mm}$$

$$\because\ d = C_1 \sqrt{\frac{M_{U.L.}}{F_{cu}\, B}} \quad \therefore\ 600 = C_1 \sqrt{\frac{265.75 * 10^6}{25 * 900}} \longrightarrow C_1 = 5.52 \longrightarrow J = 0.826$$

$$\therefore\ A_s = \frac{M_{U.L.}}{J\, F_y\, d} = \frac{265.75 * 10^6}{0.826 * 400 * 600} = 1340.5\ mm^2$$

– Check $A_{s_{min.}}$ $\qquad A_{s_{req.}} = 1340.5\ mm^2$

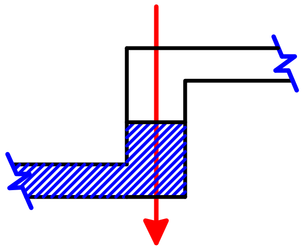
$$\mu_{min.}\, b\, d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\, d = \left(0.225 * \frac{\sqrt{25}}{400}\right) 250 * 600 = 421.8\ mm^2$$

$$\therefore\ A_{s_{req.}} > \mu_{min.}\, b\, d$$

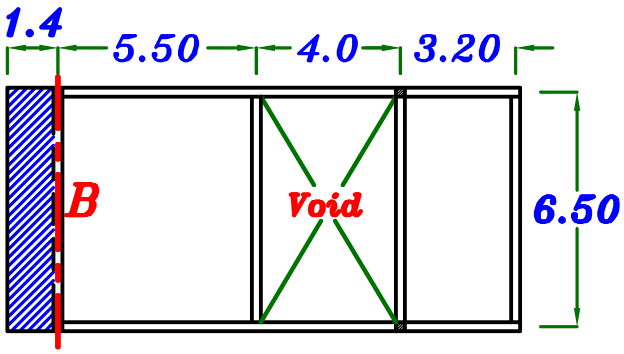
$$\therefore\ \text{Take } A_s = A_{s_{req.}} = 1340.5\ mm^2 \qquad 7\ \phi\ 16$$

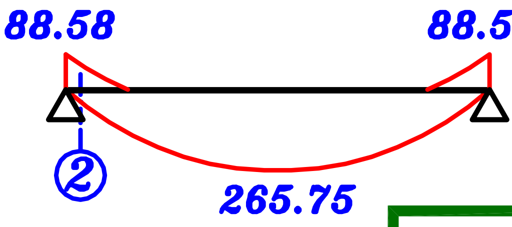
$$\therefore\ n = \frac{b - 25}{\phi + 25} = \frac{250 - 25}{16 + 25} = 5.48 = 5.0 \text{ bars}$$

Sec. ② $M_{U.L.} = 88.58$ kN.m L–Sec.



Take $d = 0.60$ m (as given in Data.)





$\boxed{\begin{array}{c}\text{كمره مقلوبه} \\ K = 0.15\end{array}}$

$$B = \left\{ \begin{array}{l} C.L. - C.L. = 1.40\ m = 1400\ mm \\ 6\ t_s + b = 6 * 150 + 250 = 1150\ mm \\ K\dfrac{L}{10} + b = 0.15 * \dfrac{6500}{10} + 250 = 347.5\ mm \end{array} \right\}$$

$$\boxed{B = 347.5\ mm}$$

$$\because d = C_1\sqrt{\frac{M_{U.L.}}{F_{cu}\ B}} \quad \therefore 600 = C_1\sqrt{\frac{88.58 * 10^6}{25 * 347.5}} \longrightarrow C_1 = 5.94 \longrightarrow J = 0.826$$

$$\therefore A_s = \frac{M_{U.L.}}{J\ F_y\ d} = \frac{88.58 * 10^6}{0.826 * 400 * 600} = 446.8\ mm^2$$

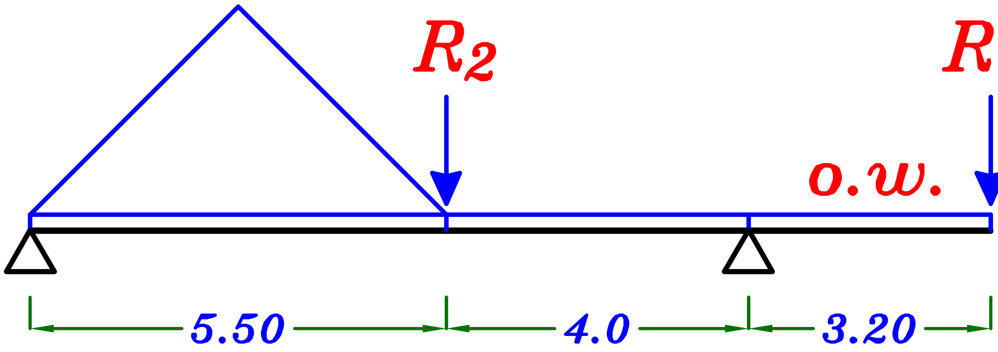
– **Check $A_{s_{min.}}$** $\qquad A_{s_{req.}} = 446.8\ mm^2$

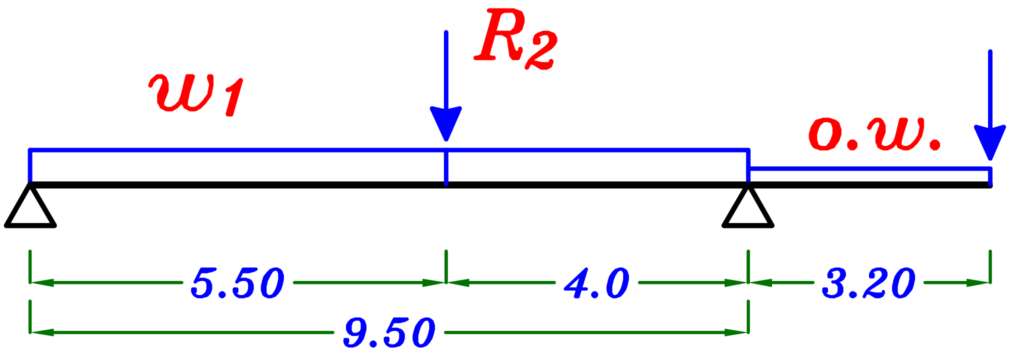
$$\mu_{min.}\ b\ d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\ d = \left(0.225 * \frac{\sqrt{25}}{400}\right) 250 * 600 = 421.8\ mm^2$$

$$\therefore A_{s_{req.}} > \mu_{min.}\ b\ d$$

$$\therefore \text{Take } A_s = A_{s_{req.}} = 446.8\ mm^2 \qquad 3\ \phi\ 16$$

G





$$\frac{\sum area}{span} = \frac{\frac{1}{2}(5.50)\left(\frac{5.50}{2}\right)}{9.50} = 0.796$$

Load For Shear = Load For Moment

$$g_{1a} = g_{1e} = o.w. + \frac{\sum area}{span} * g_s = 5.0 + 0.796\ (5.75) = 9.577\ kN\backslash m'$$

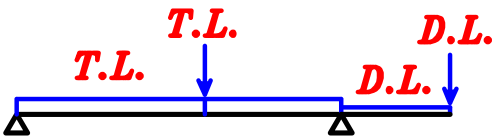
$$p_{1a} = p_{1e} = \frac{\sum area}{span} * p_s = 0.796\ (3.0) = 2.388\ kN\backslash m'$$

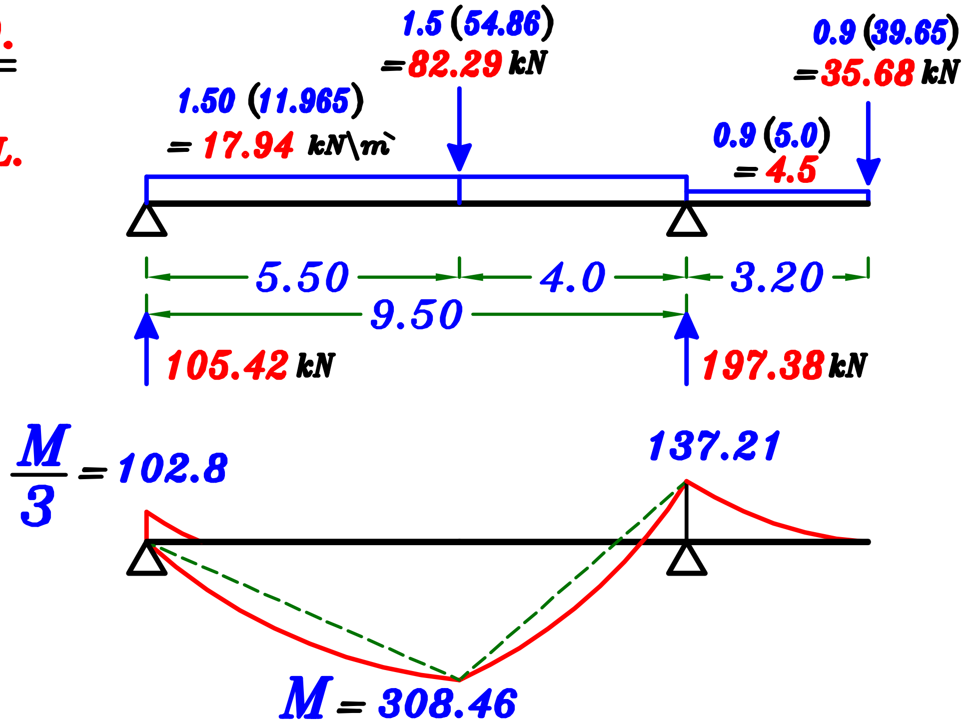
$$w_{1a} = w_{1e} = g_1 + p_1 = 9.577 + 2.388 = 11.965\ kN\backslash m'$$

$$\boxed{\begin{array}{l} g_1 = 9.577\ kN\backslash m' \text{ ---- D.L.} \\ w_1 = 11.965\ kN\backslash m' \text{ ---- T.L.} \end{array}}$$

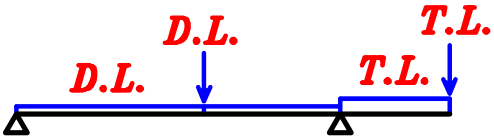
max–max B.M.D. For the Girder (G)

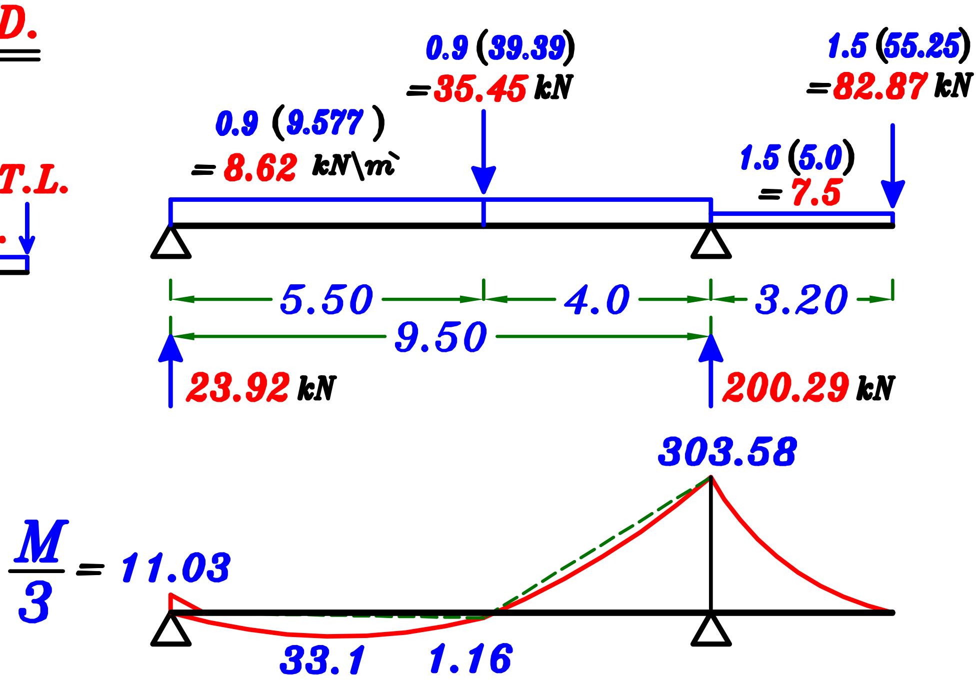
1- max. +Ve B.M.D.



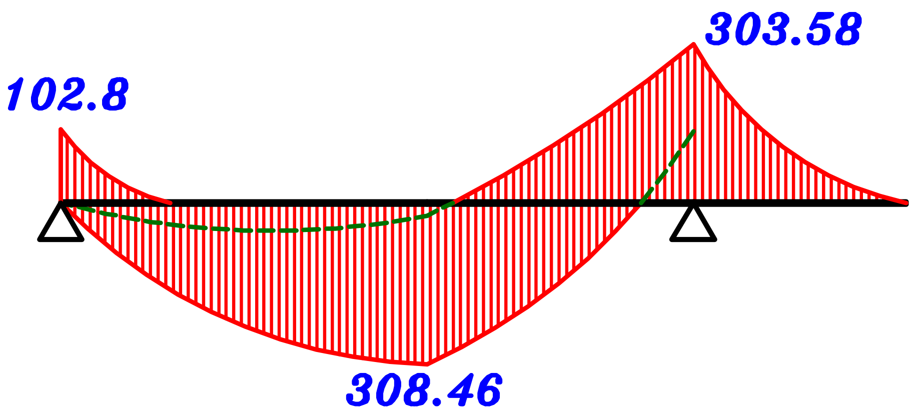


2- max. –Ve B.M.D.

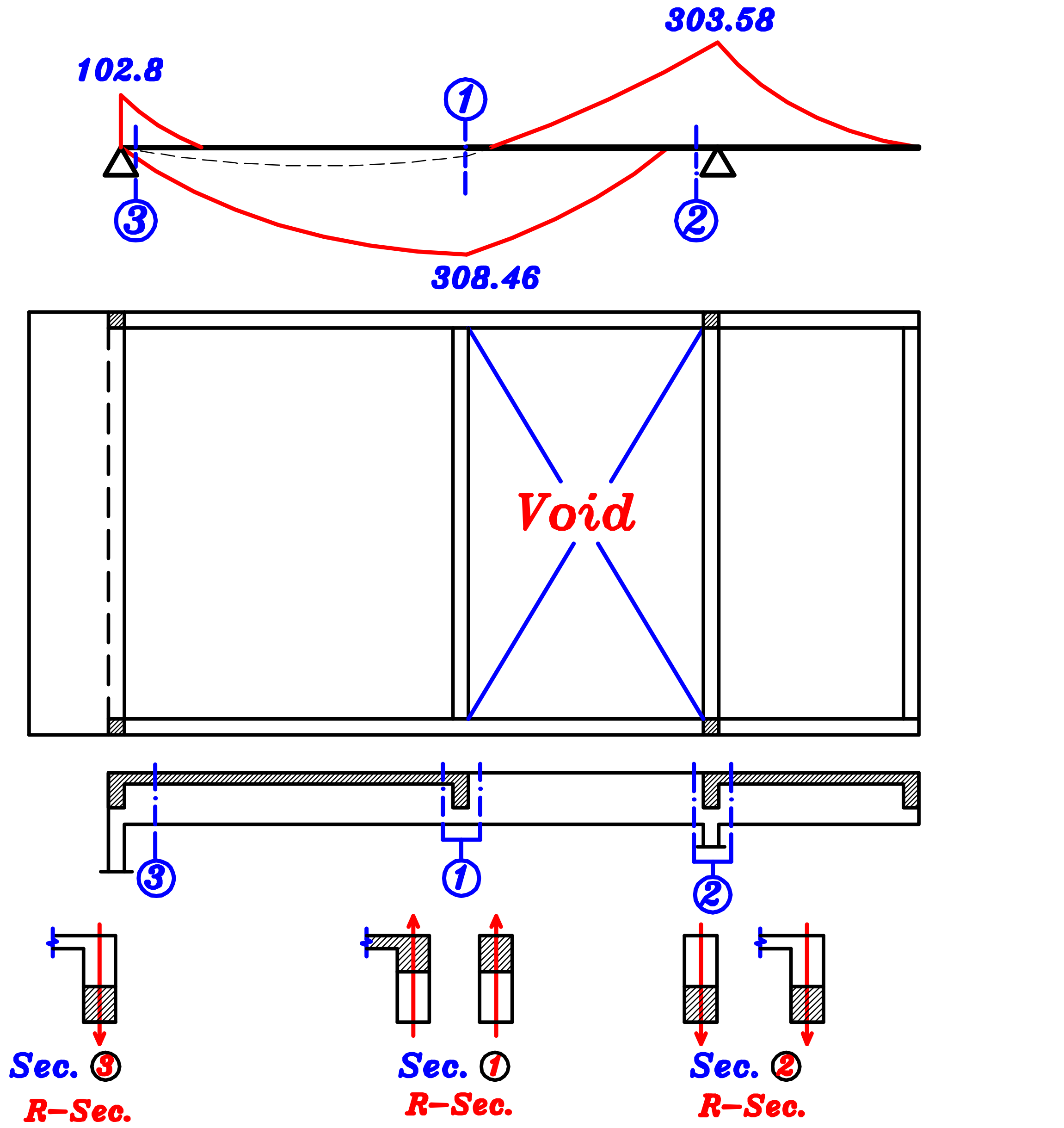




max–max B.M.D. For the Girder.



Design the critical sections For the Girder.



Sec. 1 $M_{U.L.} = 308.46$ kN.m R-Sec.

- Take C_1 between $(3.0 \longrightarrow 4.0)$ $C_1 = 3.50$

- From charts $C_1 = 3.50 \longrightarrow J = 0.78$

- Get $d = C_1 \sqrt{\dfrac{M_{U.L.}}{F_{cu}\ b}} = 3.50 \sqrt{\dfrac{308.46 * 10^6}{25 * 250}} = 777.5$ mm

- Take $\boxed{d = 800 \text{ mm}}$, $\boxed{t = 850 \text{ mm}}$

- Get $A_s = \dfrac{M_{U.L.}}{J\ F_y\ d} = \dfrac{308.46 * 10^6}{0.78 * 400 * 777.5} = 1271.5 \text{ mm}^2$

- Check $A_{s_{min.}}$ $\qquad A_{s_{req.}} = 1271.5\ mm^2$

$$\mu_{min.}\, b\, d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\, d = \left(0.225 * \frac{\sqrt{25}}{400}\right) 250 * 800 = 562.5\, mm^2$$

$$\therefore A_{s_{req.}} > \mu_{min.}\, b\, d$$

$$\therefore \text{Take } A_s = A_{s_{req.}} = 1271.5\ mm^2 \qquad 5 \phi 20$$

$$\therefore n = \frac{b - 25}{\phi + 25} = \frac{250 - 25}{20 + 25} = 5.0 \text{ bars}$$

Sec. ②

$M_{U.L.} = 303.58\ kN.m$ $\quad$ R-Sec.

Take $d = 0.80\ m$ (The same d of Sec. ①)

$$\because d = C_1 \sqrt{\frac{M_{U.L.}}{F_{cu}\, b}} \quad \therefore 800 = C_1 \sqrt{\frac{303.58 * 10^6}{25 * 250}} \longrightarrow C_1 = 3.63 \longrightarrow J = 0.788$$

$$\therefore A_s = \frac{M_{U.L.}}{J\, F_y\, d} = \frac{303.58 * 10^6}{0.788 * 400 * 800} = 1203.9\ mm^2$$

- Check $A_{s_{min.}}$ $\qquad A_{s_{req.}} = 1203.9\ mm^2$

$$\mu_{min.}\, b\, d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\, d = \left(0.225 * \frac{\sqrt{25}}{400}\right) 250 * 800 = 562.5\, mm^2$$

$$\therefore A_{s_{req.}} > \mu_{min.}\, b\, d$$

$$\therefore \text{Take } A_s = A_{s_{req.}} = 1203.9\ mm^2 \qquad 4 \phi 20$$

Sec. ③ $M_{U.L.} = 102.8$ kN.m R–Sec.

Take $d = 0.80$ m (The same d of Sec. ①)

$$\because\ d = C_1 \sqrt{\frac{M_{U.L.}}{F_{cu}\, b}} \quad \therefore\ 800 = C_1 \sqrt{\frac{102.8 * 10^6}{25 * 250}} \longrightarrow C_1 = 6.23$$

– From Charts. $C_1 = 6.23 > 4.85 \longrightarrow J = 0.826$

$$\therefore\ A_s = \frac{M_{U.L.}}{J\, F_y\, d} = \frac{102.8 * 10^6}{0.826 * 400 * 800} = 388.9\ mm^2$$

<u>Check $A_{s_{min.}}$</u> $A_{s_{req.}} = 388.9\ mm^2$

$$\mu_{min.}\, b\, d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\, d = \left(0.225 * \frac{\sqrt{25}}{400}\right) 250 * 800 = 562.5\ mm^2$$

$$\therefore\ \mu_{min.}\, b\, d > A_{s_{req.}} \xrightarrow{\text{Use}} A_{s_{min.}}$$

$$A_{s_{min.}} = 0.225 * \frac{\sqrt{F_{cu}}}{F_y}\, b\, d = \left(0.225 * \frac{\sqrt{25}}{400}\right) 250 * 800 = 562.5$$

$$1.3\ A_{s_{req.}} = 1.3 * 388.9 = 505.6$$

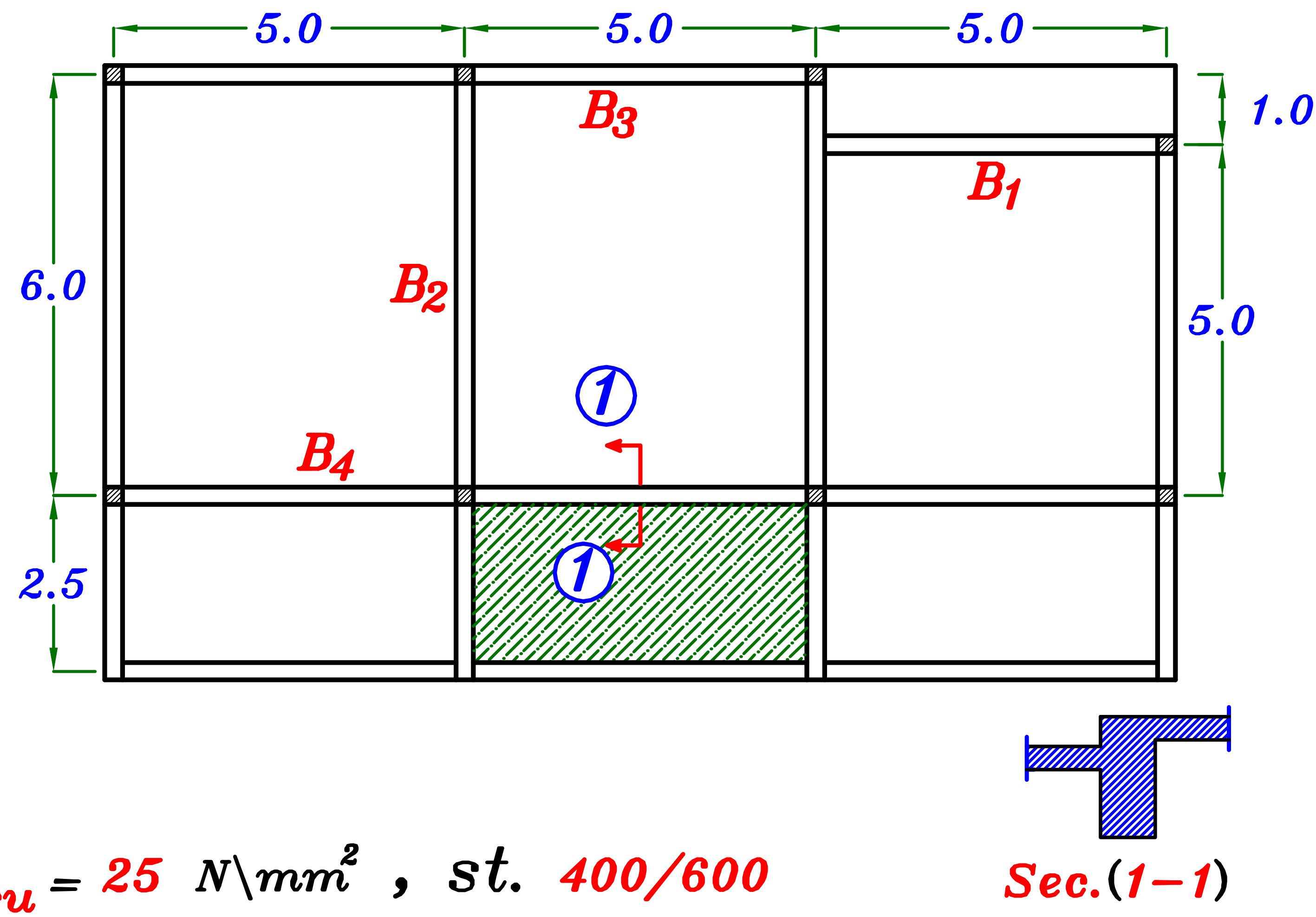
الأقل $= 505.6$

st. 400/600 $\frac{0.15}{100}\, b\, d = \frac{0.15}{100} * 250 * 800 = 300$

الأكبر $= 505.6\ mm^2$

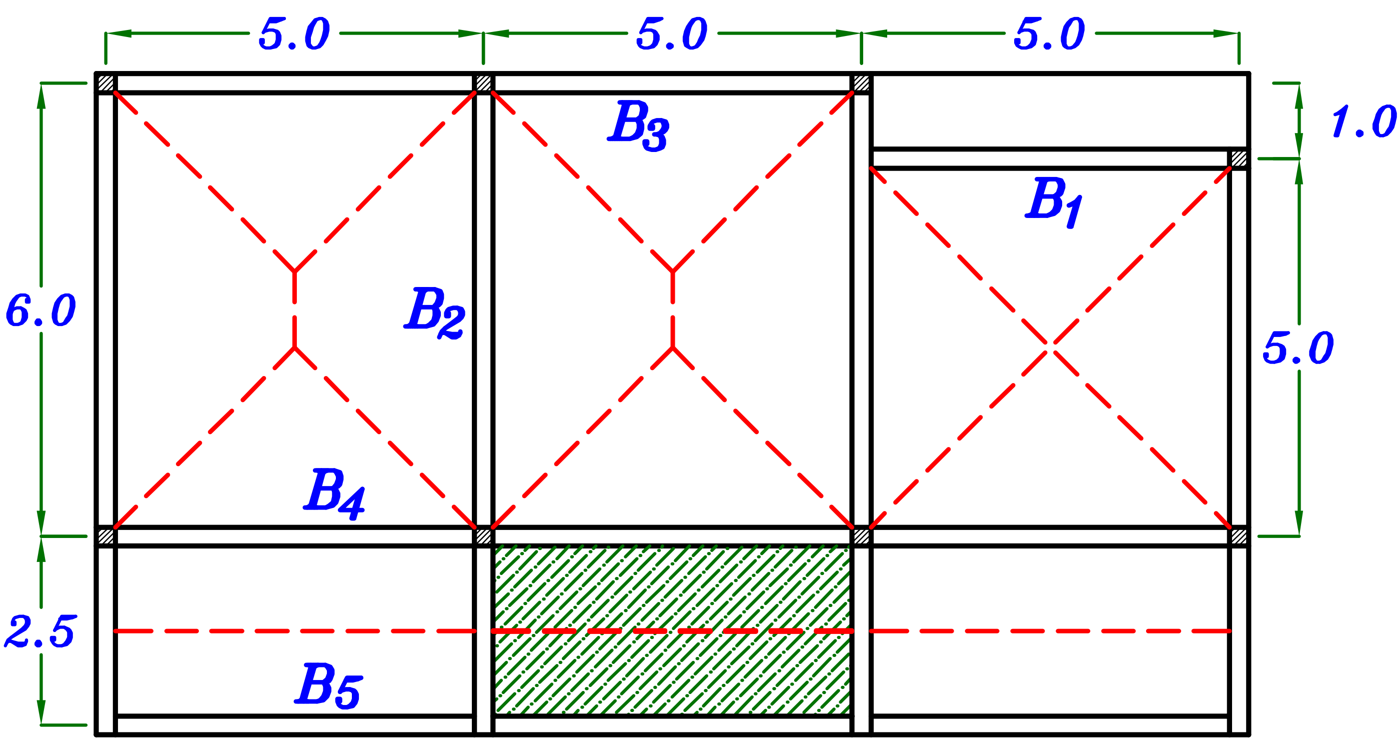
$2\ \phi 20$

Example.

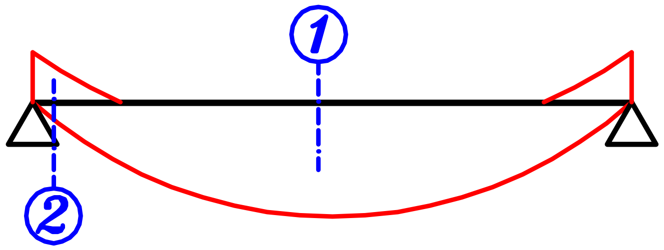


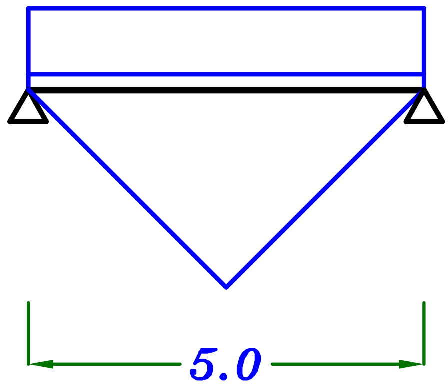
$F_{cu} = 25\ N\backslash mm^2$, st. 400/600

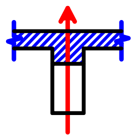
F.C. $= 2.0\ kN\backslash m^2$, L.L. $= 2.0\ kN\backslash m^2$, $t_s = 140\ mm$

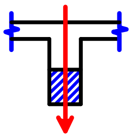


B_1





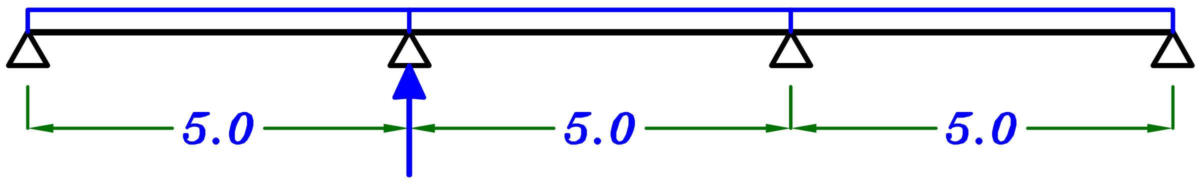
Sec. 1 T–Sec.  $K = 1.0$

Sec. 2 R–Sec. 

$\because M_T > 2\, M_R \quad \therefore$ Design T–Sec. at First.

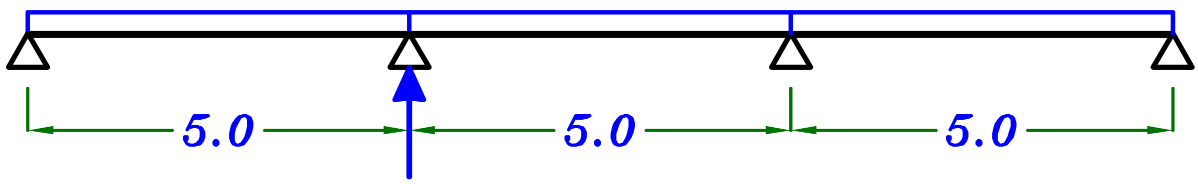
B_5

g_a



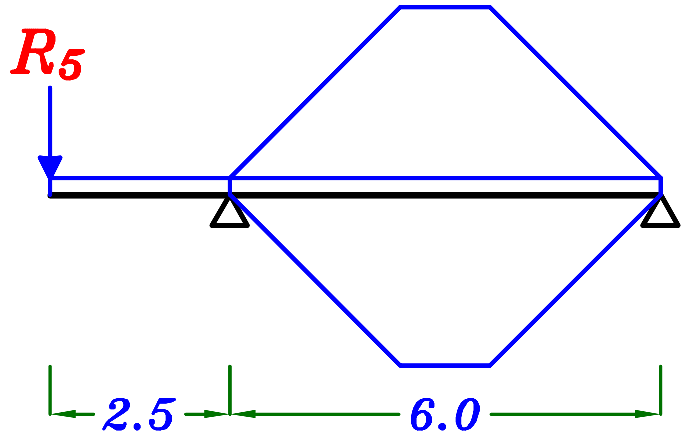
$$\boxed{R_{5D} = 1.1\ g_a\ L}$$

w_a

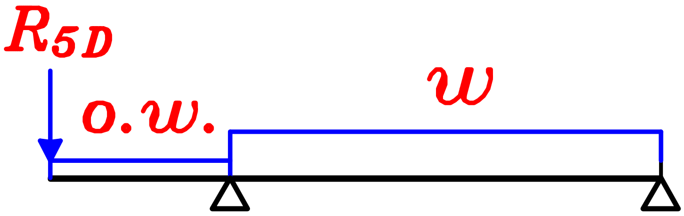


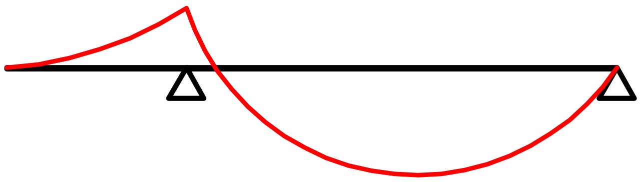
$$\boxed{R_{5T} = 1.1\ w_a\ L}$$

B_2

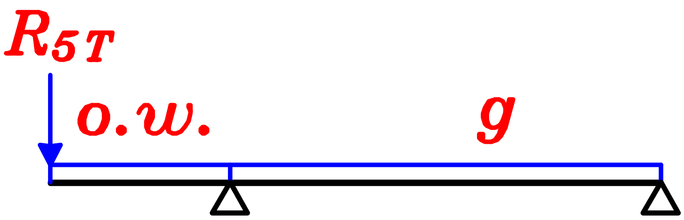


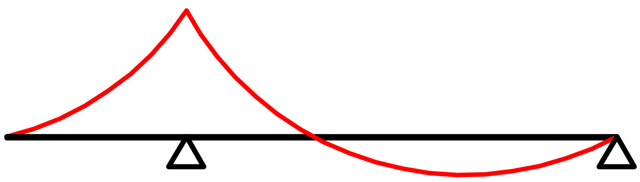
max. + Ve B.M.D.

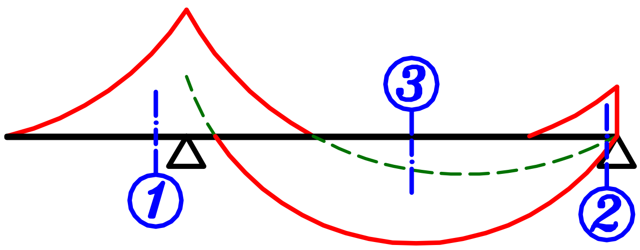




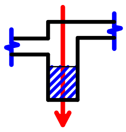
max. − Ve B.M.D.



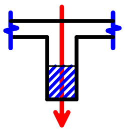




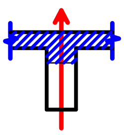
Sec. 1 R−Sec.



Sec. 2 R−Sec.



Sec. 3 T−Sec.

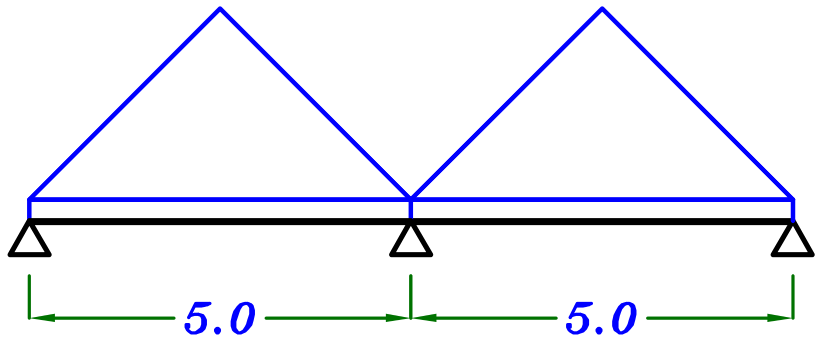


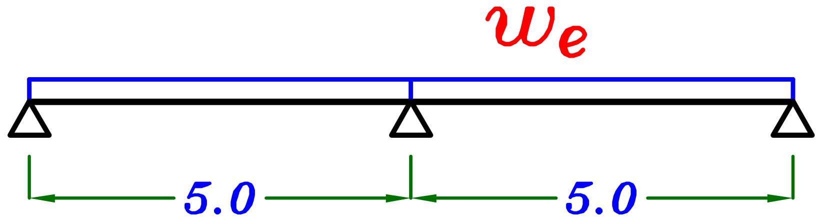
$K = 0.8$

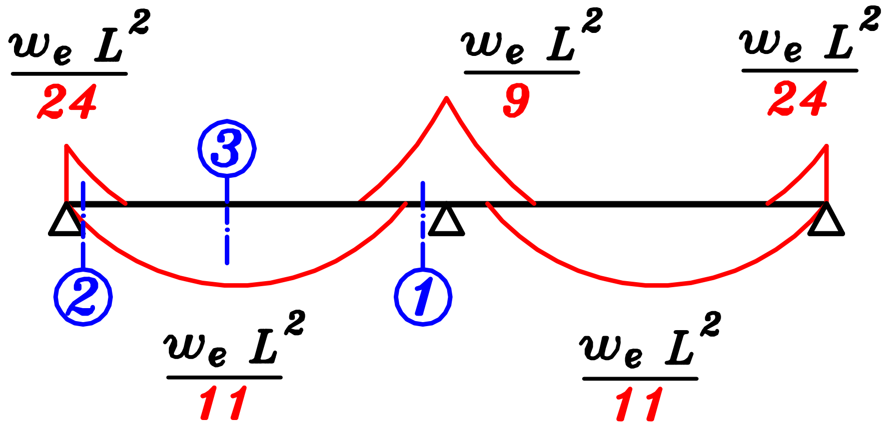
$\because M_T < 2\, M_R \quad \therefore$ Design R−Sec. at First.

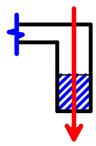
B_3

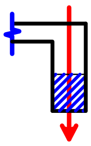
ملحوظه
لا نعمل حالات تحميل للكمرات المستمره لاننا نحفظ قيم
max–max B.M.D.

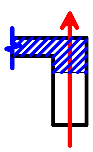






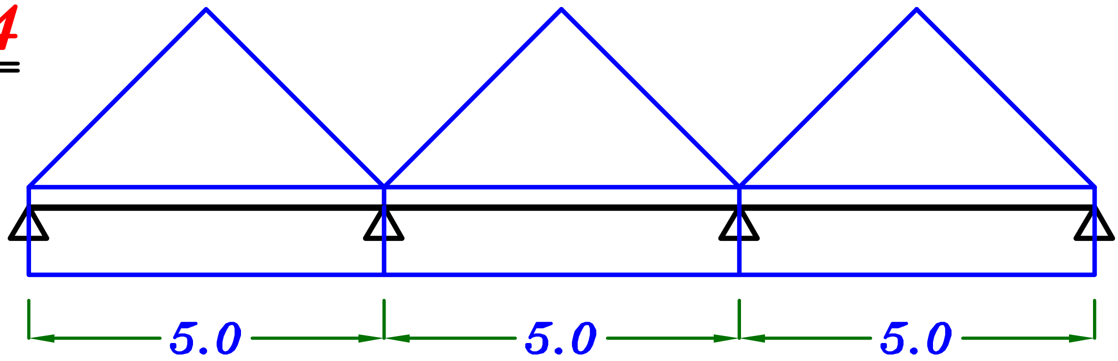
Sec. ① R–Sec. 

Sec. ② R–Sec. 

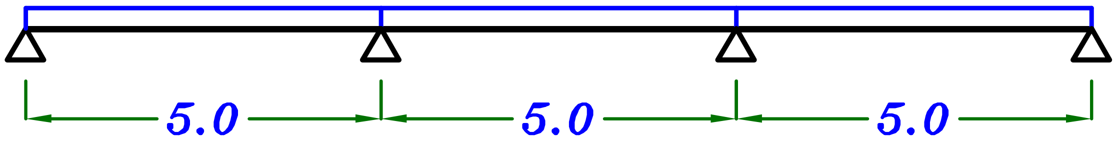
Sec. ③ L–Sec.  $K = 0.8$

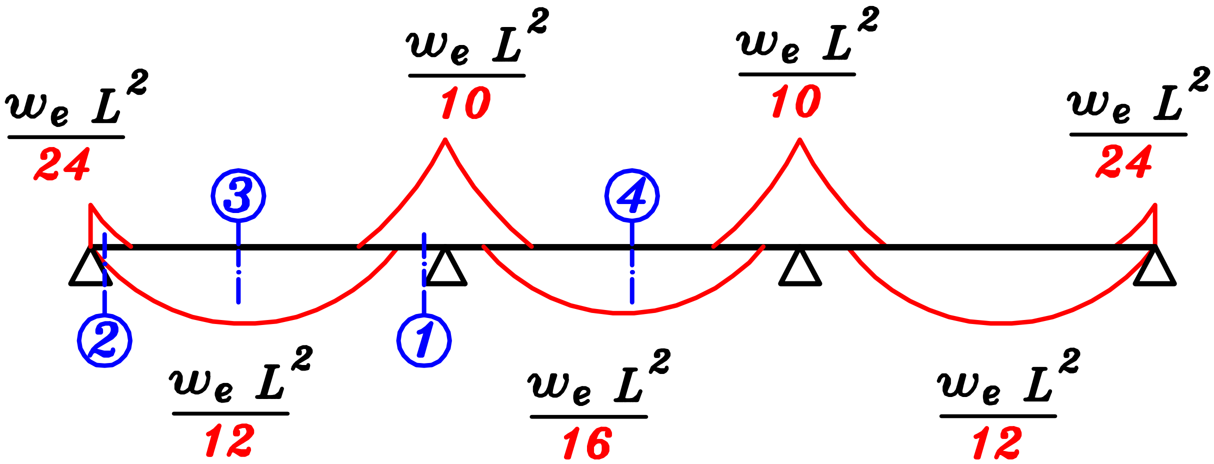
$\because M_L < 2\, M_R \quad \therefore$ Design R–Sec. at First.

B_4



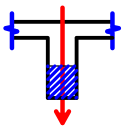
w_e

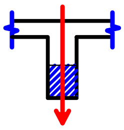


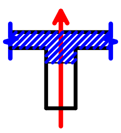


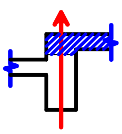
ملحوظه لا نعمل حالات تحميل للكمرات المستمره لاننا

نحفظ قيم max–max B.M.D.

Sec. 1 R–Sec. 

Sec. 2 R–Sec. 

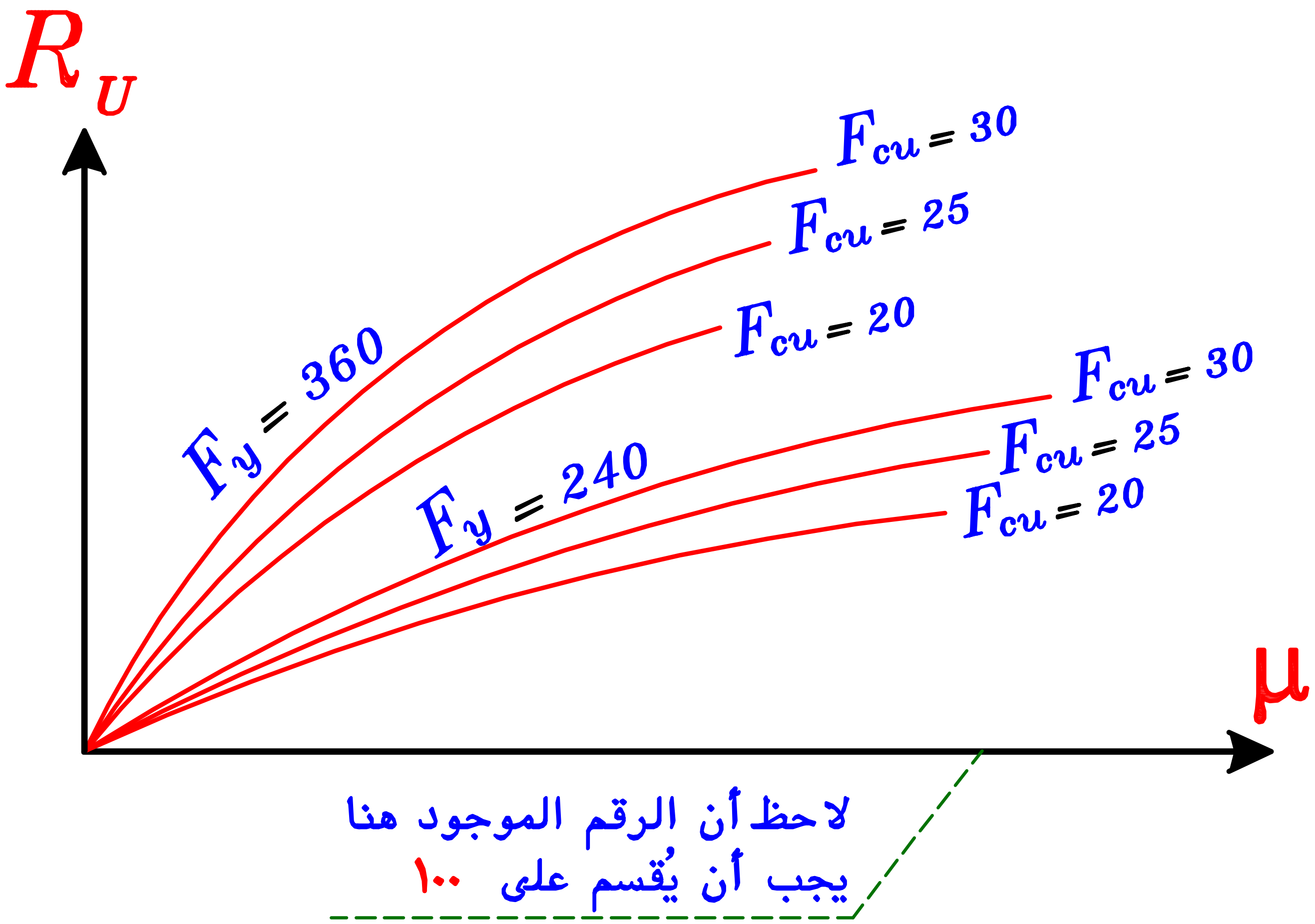
Sec. 3 T–Sec.  $K = 0.8$

Sec. 4 L–Sec.  $K = 0.7$

$\because M_T < 2\, M_R \quad \therefore$ Design R–Sec. at First.

Design of Beams Using (R_U & μ) Chart.

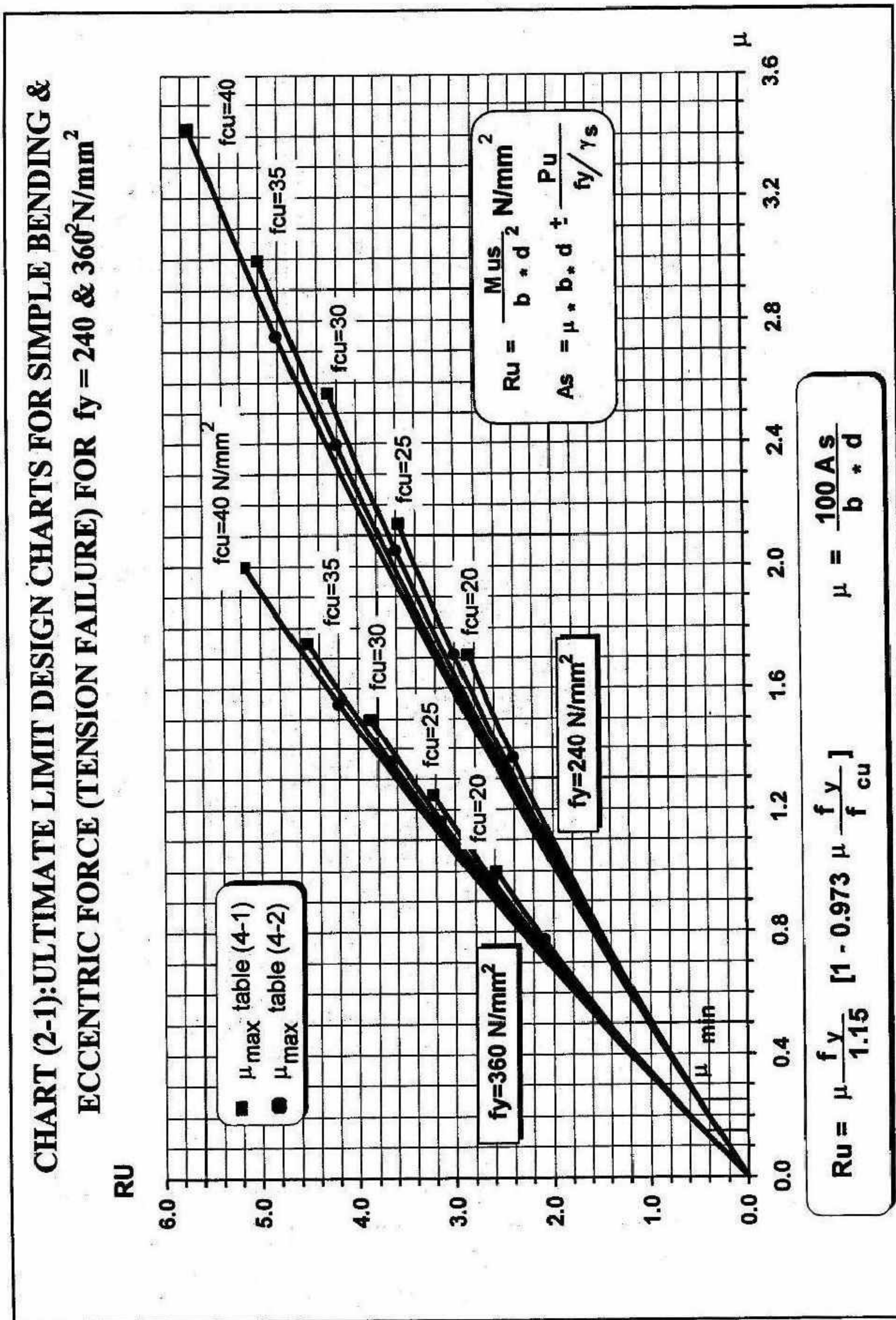
We can Get R_U , μ From Charts at Design Aids (ECCS) Pages 2-19 , 2-20



$$R_U = \frac{M_{U.L.}}{b\,d^2}$$

$$d = \sqrt{\frac{M_{U.L.}}{R_U\, b}}$$ حفظ

$$A_s = \mu\, b\, d$$ حفظ



ECCS 203-2001 Design Aids Flexure Members

Types of Problems.

Type 1

Given: F_{cu} , st. , b , $M_{U.L.}$

Req: d , A_s

Solution:

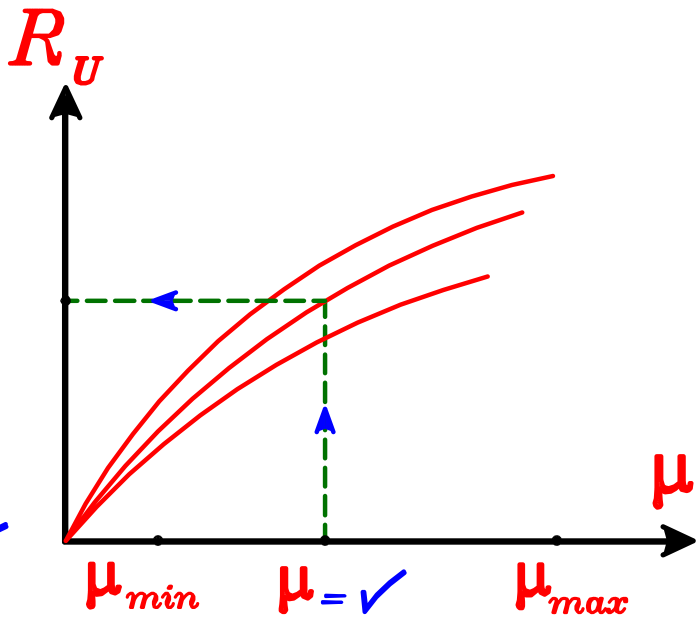
– Get $\mu_{min.} = 0.225 * \frac{\sqrt{F_{cu}}}{F_y}$

$\mu_{max.}$ ⟶ From Code Page (4–6) Table (4–1)

– Choose a value between $\mu_{min.}$, $\mu_{max.}$ ∴ $\mu = ✓$

– Get R_U

From charts.



– Get d

where: $d = \sqrt{\frac{M_{U.L.}}{R_U\, b}} = ✓$

تقرب لأقرب ٥٠ مم بالزياده

$t = d + 50\ mm = ✓$

– Get A_s

قبل التقريب

where: $A_s = \mu\, b\, d = ✓$

Example.

$F_{cu} = 25\ N\backslash mm^2$ st. 360/520

$b = 0.25\ m$ $M_{U.L.} = 300\ kN.m$

Req: Get d , A_s

Solution.

$$\mu_{min.} = 0.225 * \frac{\sqrt{F_{cu}}}{F_y} = 0.225 * \frac{\sqrt{25}}{360} = 0.00312 = 0.312\ \%$$

$$\mu_{max.} = 5.0 * 10^{-4}\ F_{cu} = 5.0\ * 10^{-4} * 25\ = 0.0125 = 1.25\ \%$$

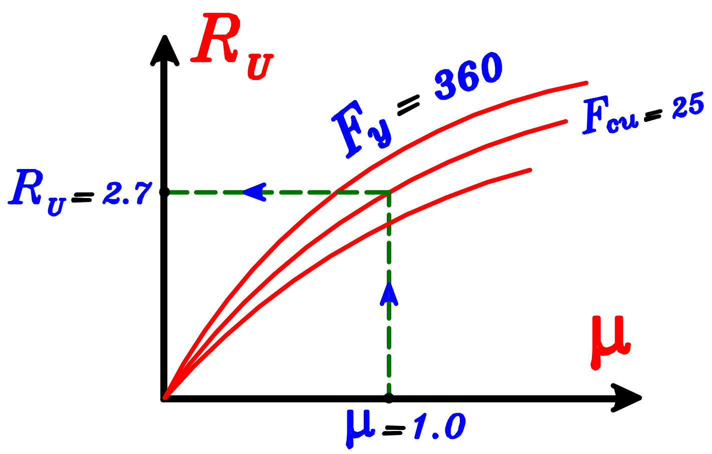
Choose a value between $\mu_{min.}$, $\mu_{max.}$ (0.46 % , 2.14 %)

$\therefore$ Take $\mu = 1.0\ \%$

From Design Aids

Page 2-19

$\therefore\ R_U = 2.7$



$$- \text{Get}\ \ d = \sqrt{\frac{M_{U.L.}}{R_U\ b}} = \sqrt{\frac{300 * 10^6}{2.70 * 250}} = 666.6\ mm$$

Take $\boxed{d = 700\ mm}$, $\boxed{t = 750\ mm}$

$$- \text{Get}\ \ A_s = \mu\ b\ d = 0.01 * 250 * 666.6 = 1666.5\ mm^2$$

7 ϕ 18

Type ②

Given: F_{cu} , st. , b , d , $M_{U.L.}$

Req: A_s , $A_{s'}$ IF Required

Solution:

Calculate $a_{max} = 0.8\left(\frac{2}{3}\right) C_b = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (F_y \backslash \delta_s)}\right] * d$

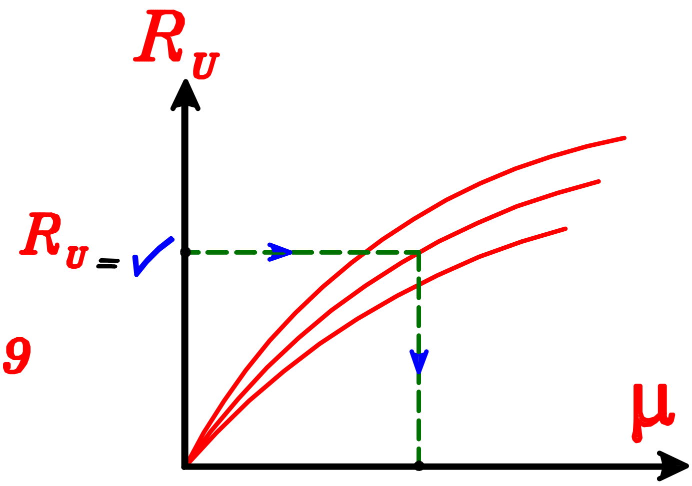
Calculate $M_{U.L._{max.}} = \frac{2}{3}\,\frac{F_{cu}}{\delta_c}\,a_{max.}\,b\left(d - \frac{a_{max.}}{2}\right)$

① IF $M_{U.L.} \leqslant M_{U.L._{max.}}$ (No need to use $A_{s'}$)

– Get $R_U = \frac{M_{U.L.}}{b\,d^2}$

– Get μ

From Design Aids Page 2–19



– Get $A_s = \mu\, b\, d$

– Check $A_{s_{min.}}$

② IF $M_{U.L.} > M_{U.L._{max.}}$ (We need to use $A_{s'}$)

– Get $A_{s'}$ From $\triangle M = M_{U.L.} - M_{U.L._{max.}} = A_{s'}\frac{F_y}{\delta_s}(d - d')$

– Get $A_s = A_{s_{max.}} + A_{s'} = \mu_{max.}\, b\, d + A_{s'}$

– Check $\frac{A_{s'}}{A_s} \leqslant 0.40$

Example.

$F_{cu} = 25\ N\backslash mm^2$ st. 360/520 $M_{U.L.} = 200\ kN.m$

$b = 0.25\ m$ $d = 0.7\ m$

Get A_s , $A_{s`}$ IF Required

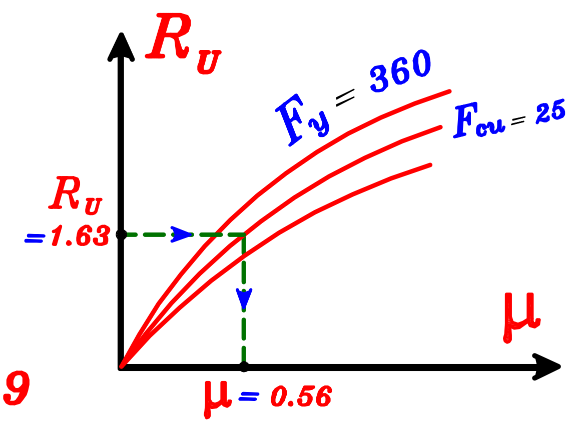
Solution.

$$a_{max} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (F_y\backslash \gamma_s)}\right] * d = 0.35\,d = 0.35 * 700 = 245\ mm$$

$$M_{U.L._{max}} = \frac{2}{3}\frac{F_{cu}}{\gamma_c}\,a_{max}\,b\left(d - \frac{a_{max}}{2}\right) = \frac{2}{3}\left(\frac{25}{1.5}\right)(245)(250)\left(700 - \frac{245}{2}\right) = 393020833\ N.mm$$

$$= 393\ kN.m$$

$\because M_{U.L.} < M_{U.L.}$ $\therefore$ No need to use $A_{s`}$



$- $ Get $R_U = \dfrac{M_{U.L.}}{b\ d^2} = \dfrac{200 * 10^6}{250 * 700^2} = 1.63$

$- $ Get μ From Design Aids Page 2–19

$$\mu = 0.565\ \%$$

$- $ Get $A_s = \mu\, b\, d = \dfrac{0.565}{100}(250)(700) = 989\ mm^2$

$- $ Check $A_{s_{min.}}$ $A_{s_{req.}} = 989\ mm^2$

$$\mu_{min.}\, b\, d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\, d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 250 * 700 = 546.8\ mm^2$$

$\therefore A_{s_{req.}} > \mu_{min.}\, b\, d$

$\therefore$ Take $A_s = A_{s_{req.}} = 989\ mm^2$ 5 ϕ 16

Example.

$F_{cu} = 25$ N\mm^2 st. 360/520 $M_{U.L.} = 500$ kN.m

$b = 0.25$ m $d = 0.70$ m

Get A_s , $A_{s'}$ IF Required

Solution.

$$a_{max} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600+(F_y\backslash\gamma_s)}\right]*d = 0.35\,d = 0.35*700 = 245 \text{ mm}$$

$$M_{U.L.\,max} = \frac{2}{3}\frac{F_{cu}}{\gamma_c}\,a_{max}\,b\left(d-\frac{a_{max}}{2}\right) = \frac{2}{3}\left(\frac{25}{1.5}\right)(245)(250)\left(700-\frac{245}{2}\right) = 393020833 \text{ N.mm}$$

$$= 393 \text{ kN.m}$$

$\because M_{U.L.} > M_{U.L.\,max.}$ $\therefore$ We need to use $A_{s'}$

– Get $\Delta M = M_{U.L.} - M_{U.L.\,max.} = 500 - 393 = 107$ kN.m

– Get $A_{s'}$ From $\Delta M = A_{s'}\dfrac{F_y}{\gamma_s}(d-d')$

$$\therefore 107*10^6 = A_{s'}\left(\frac{360}{1.15}\right)(700-50) \longrightarrow A_{s'} = 525 \text{ mm}^2$$

$\boxed{3\,\phi\,16}$

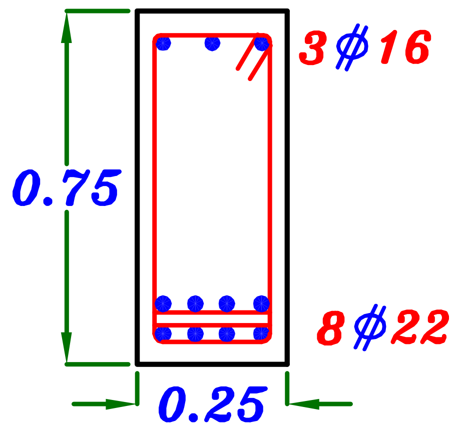
$$\mu_{max.} = 5*10^{-4}F_{cu} = 5*10^{-4}*25 = 0.0125$$

From Code Page (4–7) Table (1–4)

$$-\ A_s = \mu_{max.}\,b\,d + A_{s'} = 0.0125(250)(700) + 525 = 2712 \text{ mm}^2$$

$\boxed{8\,\phi\,22}$

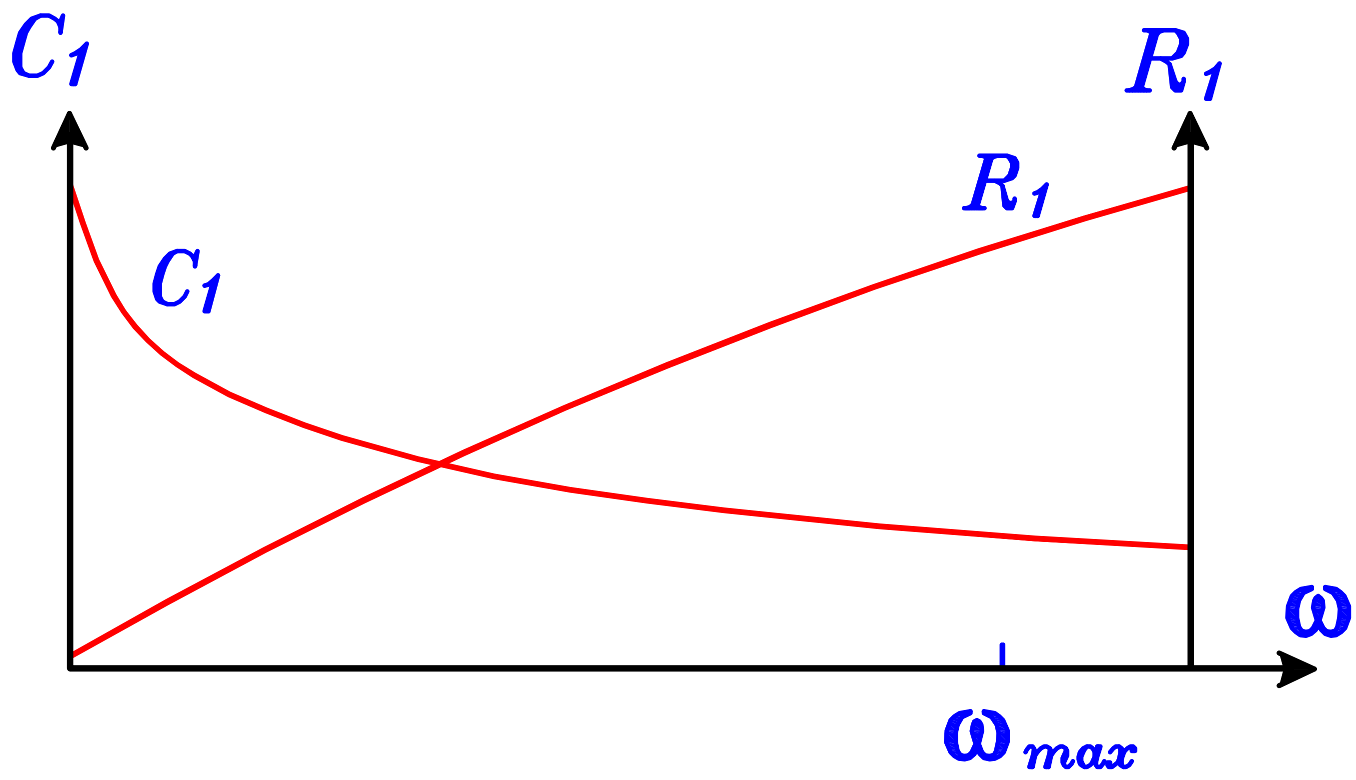
$$-\text{ Check } \frac{A_{s'}}{A_s} = \frac{525}{2712} = 0.193 < 0.40 \ \therefore \text{ o.k.}$$



Design of Beams Using (R_1 & ω) Chart.

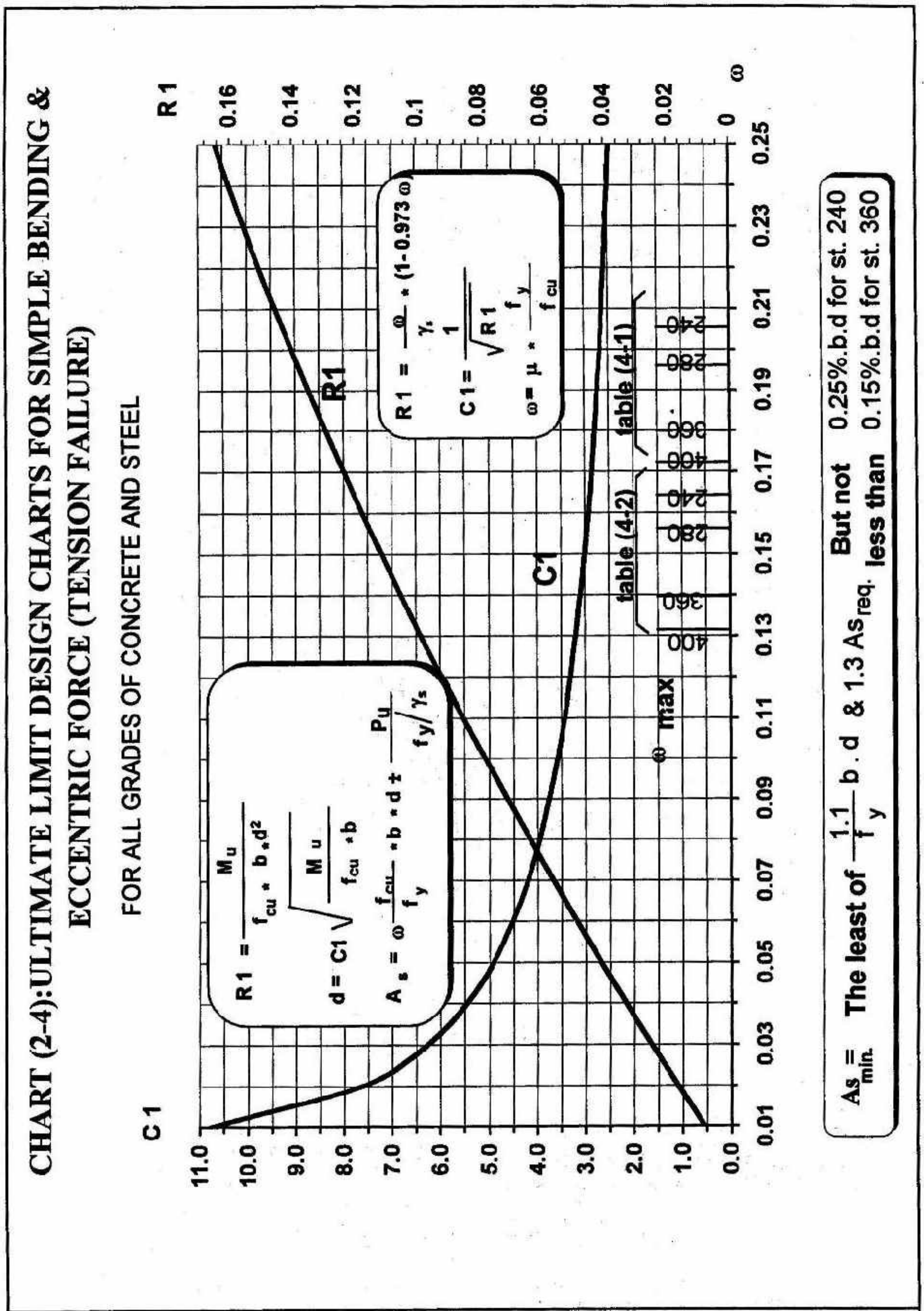
We can Get R_1 , ω From Charts

at Design Aids (ECCS) Page 2–22



$$R_1 = \frac{M_{U.L.}}{F_{cu}\, b\, d^2} = \frac{\omega}{\gamma_s} * (1 - 0.973\, \omega)$$

$$A_s = \omega * \frac{F_{cu}}{F_y} * b\, d$$



ECCS 203-2001 Design Aids

Flexure Members

Types of Problems.

Type ①

Given: F_{cu} , st. , b , $M_{U.L.}$

Req: d , A_s

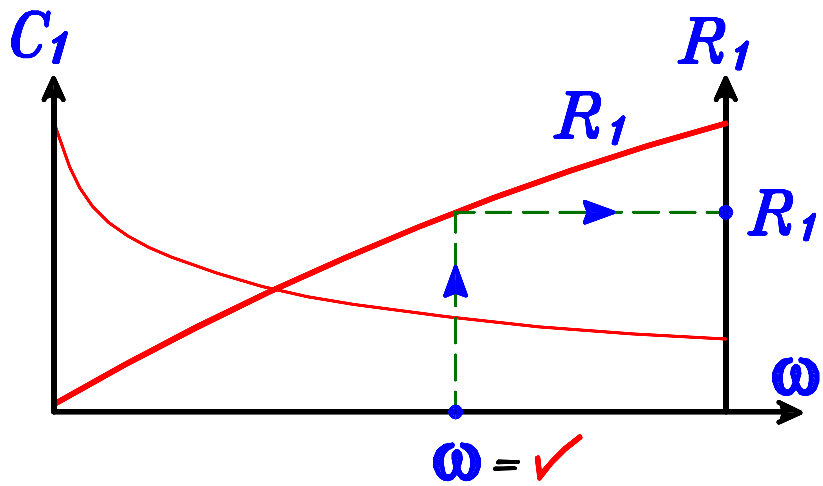
Solution:

– Take $\mu = \dfrac{A_s}{b\,d} = \omega * \dfrac{F_{cu}}{F_y} = \dfrac{1}{100}$

∴ Take $\boxed{\omega = \dfrac{1}{100} * \dfrac{F_y}{F_{cu}}}$

– Get R_1

From chart



– Get d From

$$d = \sqrt{\frac{M_{U.L.}}{R_1\,F_{cu}\,b}} = ✓$$ تقرب لأقرب ٥٠ مم بالزياده

$$t = d + 50\ mm = ✓$$

– Get $A_s = \omega * \dfrac{F_{cu}}{F_y} * \underbrace{b\,d}_{\text{قبل التقريب}} = ✓$

Example.

$F_{cu} = 25\ N\backslash mm^2$ st. 360/520

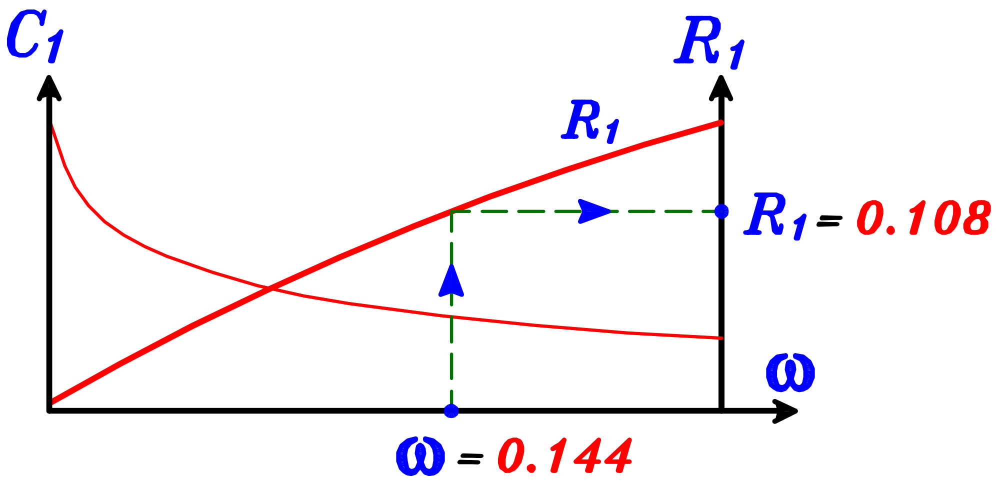
$b = 0.25\ m$ $M_{U.L.} = 300\ kN.m$

Req: Get d , A_s

Take $\omega = \dfrac{1}{100} * \dfrac{F_y}{F_{cu}} = \dfrac{1}{100} * \dfrac{360}{25} = 0.144$

– From chart

Get R_1



$\omega = 0.144 \longrightarrow R_1 = 0.108$

– Get $d = \sqrt{\dfrac{M_{U.L.}}{R_1\ F_{cu}\ b}} = \sqrt{\dfrac{300 * 10^6}{0.108 * 25 * 250}} = 666.6\ mm$

Take $\boxed{d = 700\ mm}$, $\boxed{t = 750\ mm}$

– Get $A_s = \omega * \dfrac{F_{cu}}{F_y} * b\,d = 0.144 * \dfrac{25}{360} * 250 * 666.6$

$= 1666.5\ mm^2$ 7 ϕ 18

Type ②

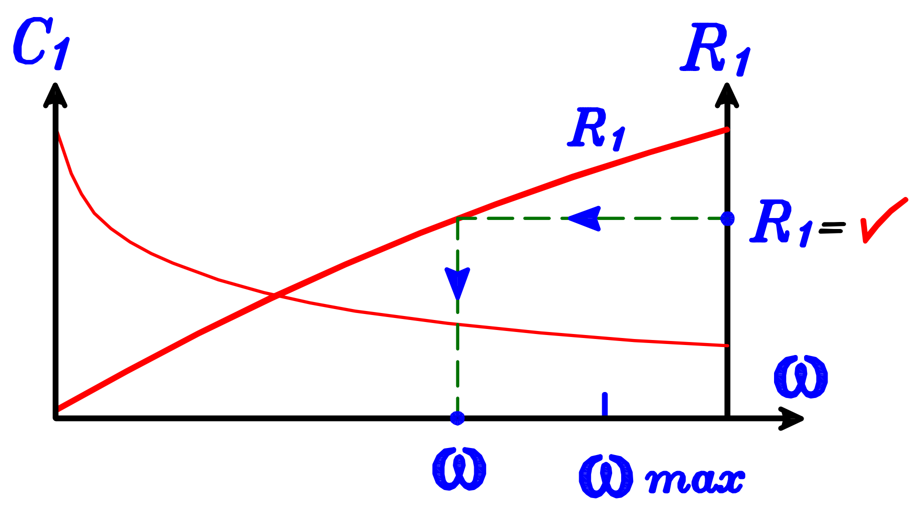
Given: F_{cu} , st. , b , d , $M_{U.L.}$

Req: A_s , $A_{s}^{`}$ IF Required

Solution:

– Get R_1 From $R_1 = \dfrac{M_{U.L.}}{F_{cu}\, b\, d^2}$

– Get ω From chart



– IF $\omega < \omega_{max}$

Get A_s From $A_s = \omega * \dfrac{F_{cu}}{F_y} * b\, d$

– Check $A_{s_{min.}}$

– IF $\omega > \omega_{max}$ $\longrightarrow$ The Section is Over Reinforced Section.

* Increase Dimensions

* Use $A_{s}^{`}$ From (ECCS) Pages 2–28 & 2–29

Example.

$F_{cu} = 25 \ N\backslash mm^2$, st. 360/520 , $M_{U.L.} = 200$ kN.m

$b = 0.25$ m , $d = 0.70$ m

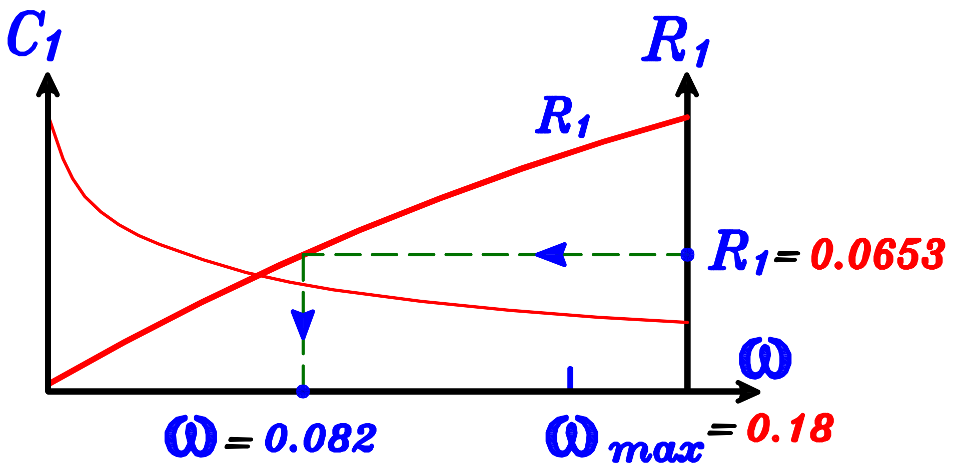
Get A_s , $A_{s`}$ IF Required

Solution.

– Get $R_1 = \dfrac{M_{U.L.}}{F_{cu}\, b\, d^2} = \dfrac{200 * 10^6}{25 * 250 * 700^2} = 0.0653$

– Get ω

From chart



$R_1 = 0.0653 \longrightarrow \omega = 0.082 < \omega_{max}$

$\therefore$ No need to use $A_{s`}$

Get $A_s = \omega * \dfrac{F_{cu}}{F_y} * b\, d = 0.082 * \dfrac{25}{360} * 250 * 700$

$= 996.5 \ mm^2$

– Check $A_{s_{min.}}$ $\qquad A_{s_{req.}} = 996.5 \ mm^2$

$\mu_{min.}\, b\, d = \left(0.225 * \dfrac{\sqrt{F_{cu}}}{F_y}\right) b\, d = \left(0.225 * \dfrac{\sqrt{25}}{360}\right) 250 * 700 = 546.8 \ mm^2$

$\therefore A_{s_{req.}} > \mu_{min.}\, b\, d$

$\therefore$ Take $A_s = A_{s_{req.}} = 996.5 \ mm^2$ $\qquad$ 5 ϕ 16

– IF $\omega > \omega_{max}$ ⟶ The Section is Over Reinforced Section.

* Increase Dimensions

* OR Use A_s' From (ECCS) Pages 2–28 & 2–29

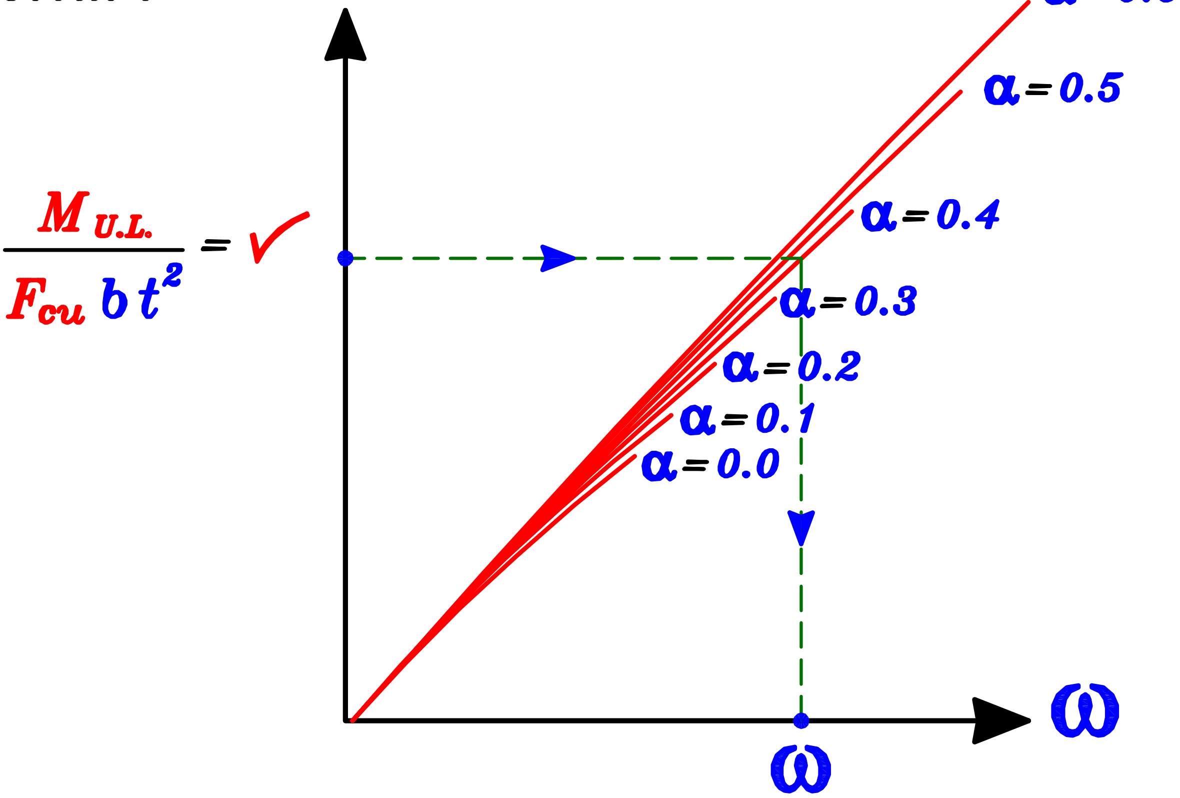
Choosing the Chart depends on F_y

– Choose α (Better choose $\alpha = 0.2$ to $\alpha = 0.40$)

– Calculate $$\frac{M_{U.L.}}{F_{cu}\, b\, t^2} = \checkmark$$

– From Chart $\frac{M_{U.L.}}{F_{cu}\, b\, t^2}$

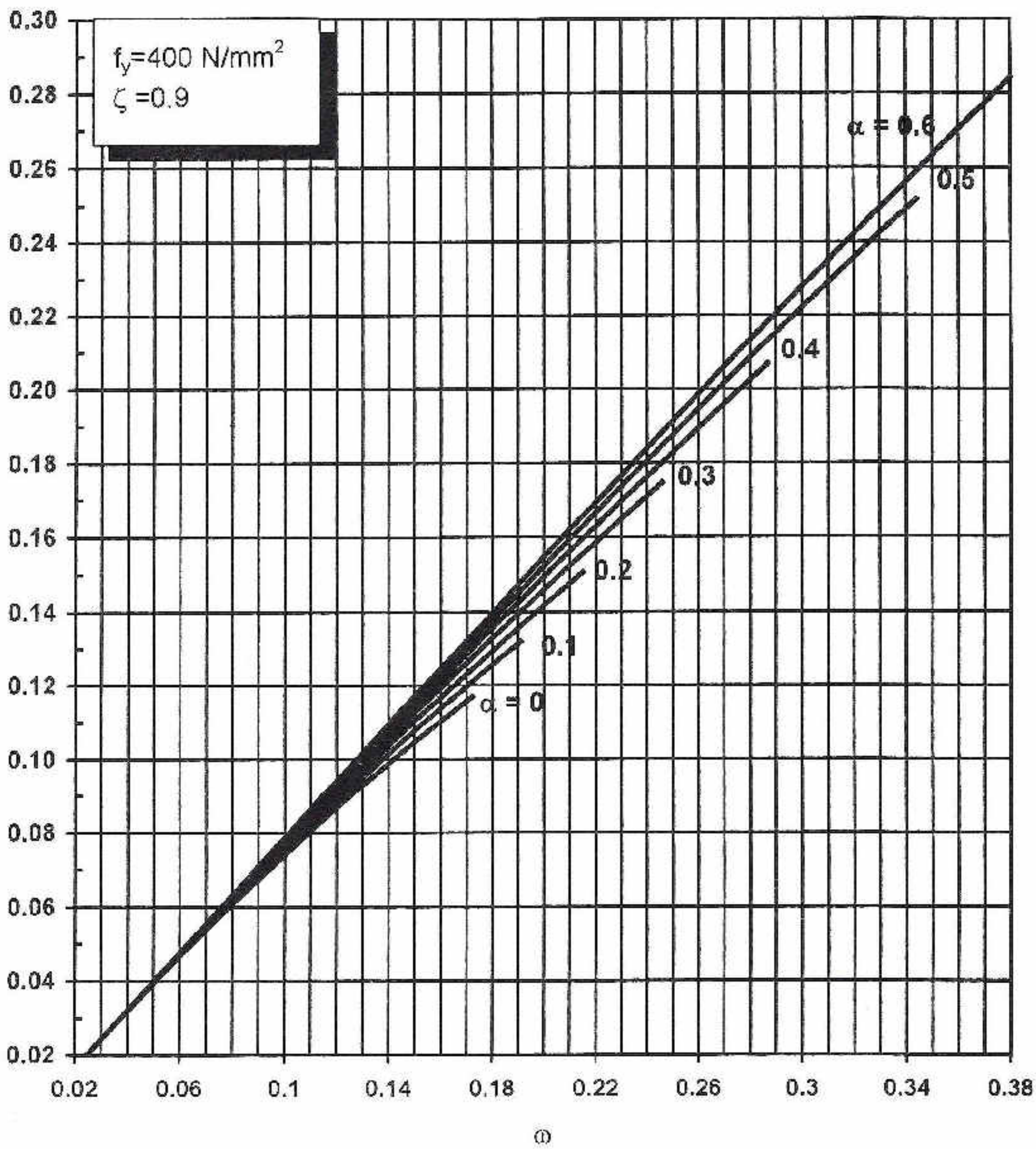
Get ω

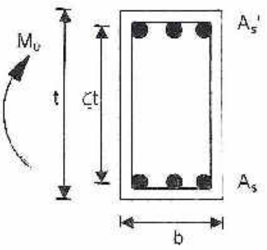


– Get $$A_s = \omega * \frac{F_{cu}}{F_y} * b\, d$$

– Get $$A_s' = \alpha * A_s$$

Chart (2-6): Ultimate Limit Design Chart for Doubly Reinforced Sections





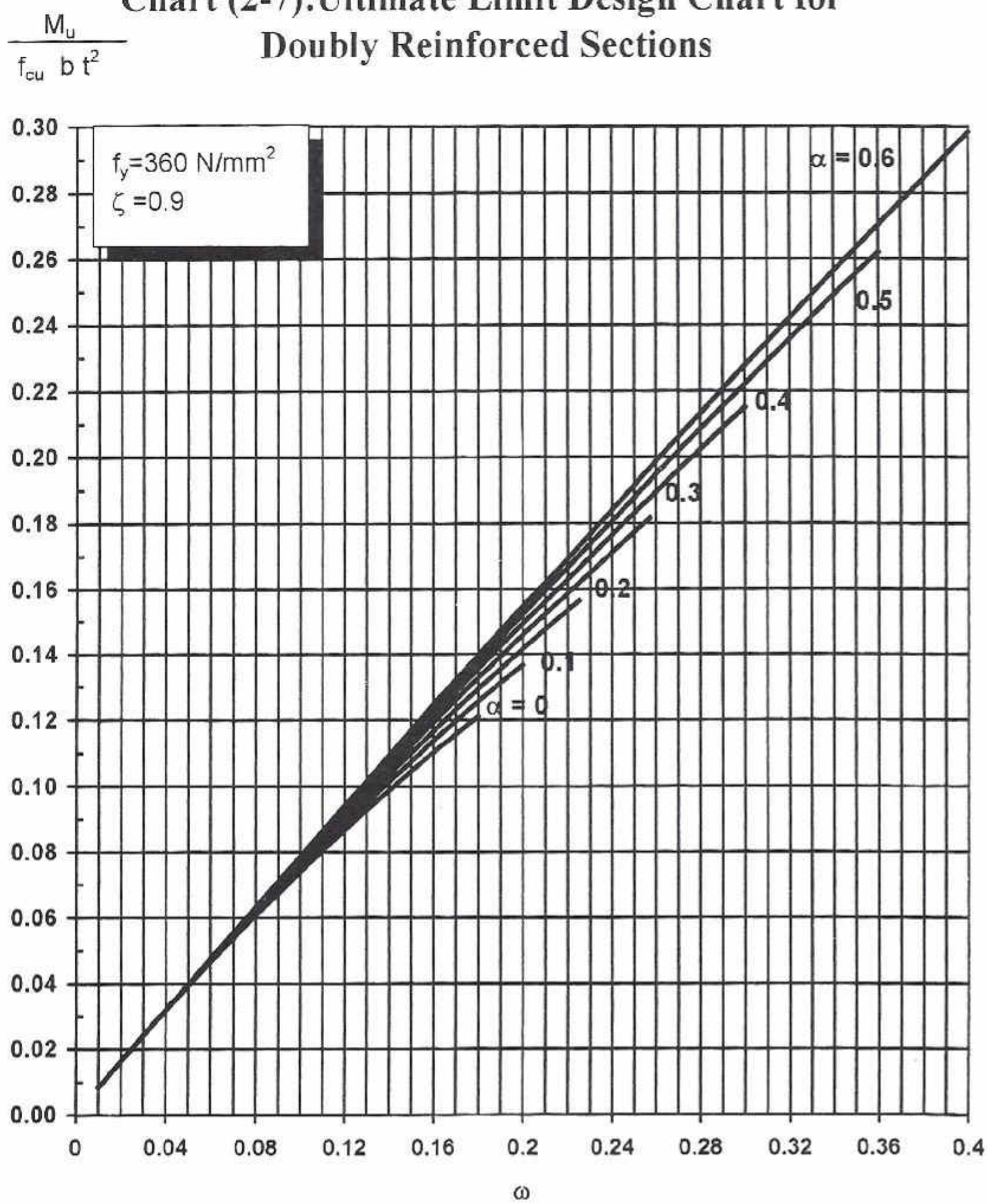
$\mu = \omega\ f_{cu}/f_y$

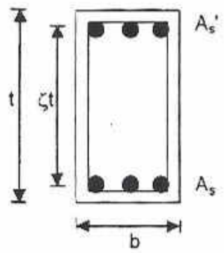
$A_s = \mu\ b\ t$

$A'_s = \alpha\ As$

ECCS 203-2001-Design Aids — Doubly Reinforced

Chart (2-7): Ultimate Limit Design Chart for Doubly Reinforced Sections





$\mu = \omega\ f_{cu}/f_y$

$A_s = \mu\ b\ t$

$A'_s = \alpha\ As$

ECCS 203-2001-Design Aids Doubly Reinforced

Example.

$F_{cu} = 25\ N\backslash mm^2$, st. 360/520 , $M_{U.L.} = 500$ kN.m

$b = 0.25\ m$, $d = 0.70\ m$

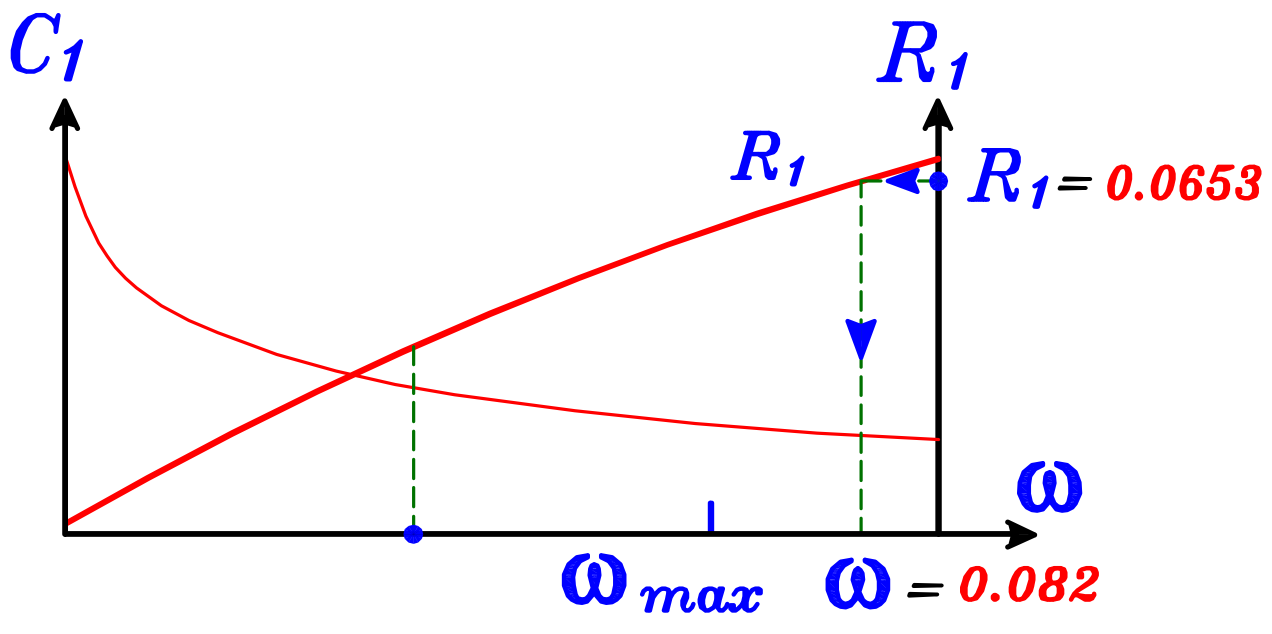
Get A_s , $A_{s\grave{}}$ IF Required

Solution.

– Get $R_1 = \dfrac{M_{U.L.}}{F_{cu}\, b\, d^2} = \dfrac{500 * 10^6}{25 * 250 * 700^2} = 0.163$

– Get ω

From chart Pages 2–22

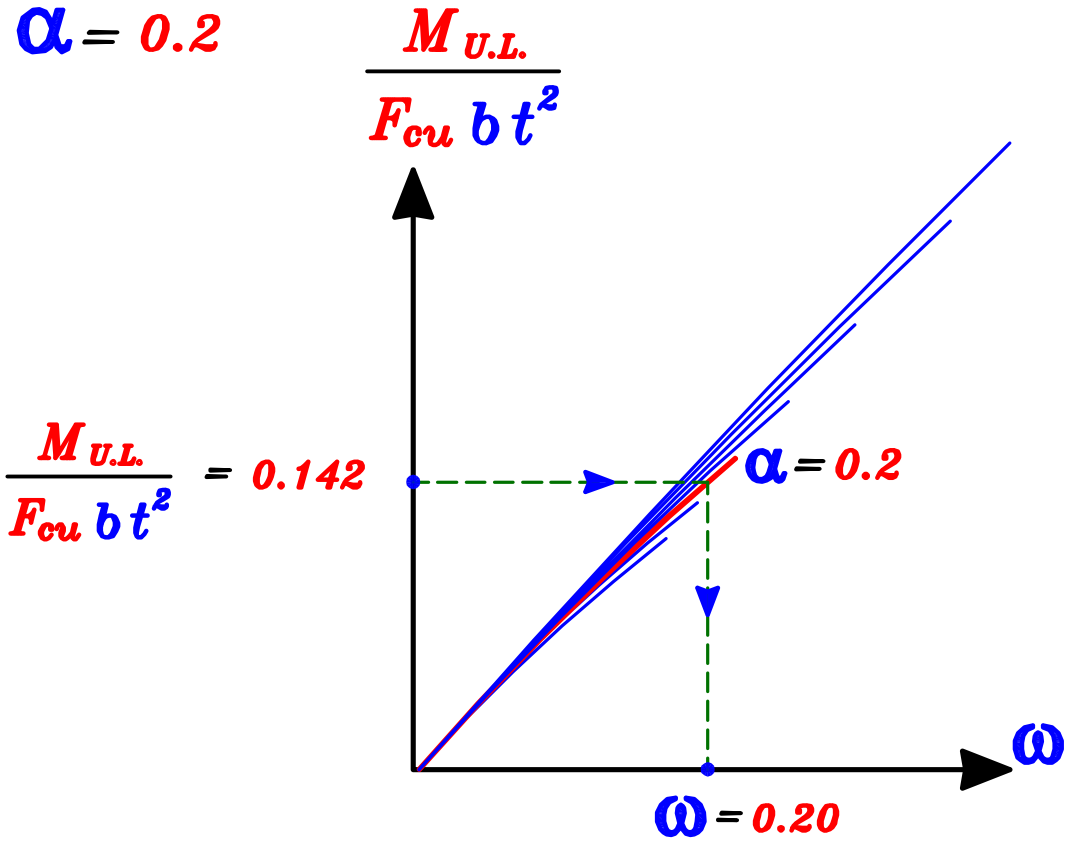


$R_1 = 0.163 \longrightarrow \omega = 0.248 > \omega_{max}$

$\therefore$ We need to use $A_{s\grave{}}$ From (ECCS) Pages 2–29

From Charts (ECCS) Pages 2–29

Choose $\alpha = 0.2$



$$\frac{M_{U.L.}}{F_{cu}\, b\, t^2} = \frac{500 * 10^6}{25 * 250 * 750^2} = 0.142 \longrightarrow \omega = 0.20$$

Get $A_s = \omega * \frac{F_{cu}}{F_y} * b\,d = 0.20 * \frac{25}{360} * 250 * 700$

$$= 2430.5 \text{ mm}^2 \qquad 7\phi 22$$

– Get $A_s` = \alpha * A_s = 0.20 * 2430.5 = 486.1 \text{ mm}^2$

$3\phi 16$